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ABSTRACT

This guide was prepared to assist elementary teachers in planning and implementing an activity-centered, conceptually-based science program. The guide consists of the following major sections: (1) Point-of-View, which sets forth a description of science, its role in the curriculum, the role of the teacher, and evaluation procedures which are compatible with a science program based on the active involvement of children in the learning process; (2) Objectives, which describes awarenesses, attitudes, skills, and understandings that should be developed through elementary science; (3) Process Skills, which identifies eleven basic skills necessary for effective "sciencing." A summary chart illustrates the interrelatedness of skills at four stages in the elementary school. Teachers can guide skill development of individual children by means of the sequence described; (4) Planning for Safety, which describes safety conditions important in the program; (5) Conceptual Areas, which outlines and classifies the major content of elementary science into the following nine conceptual areas: Adaptation, Change, Equilibrium, Interrelationships, Motion, Organization, Space, Time, and Variety. Each of the nine areas is divided into five subsections: Living Things, Matter and Energy, Earth, The Universe, and Man and Technology; and (6) Suggested Bibliography which lists professional books for science in the elementary school. (Authors/JR)

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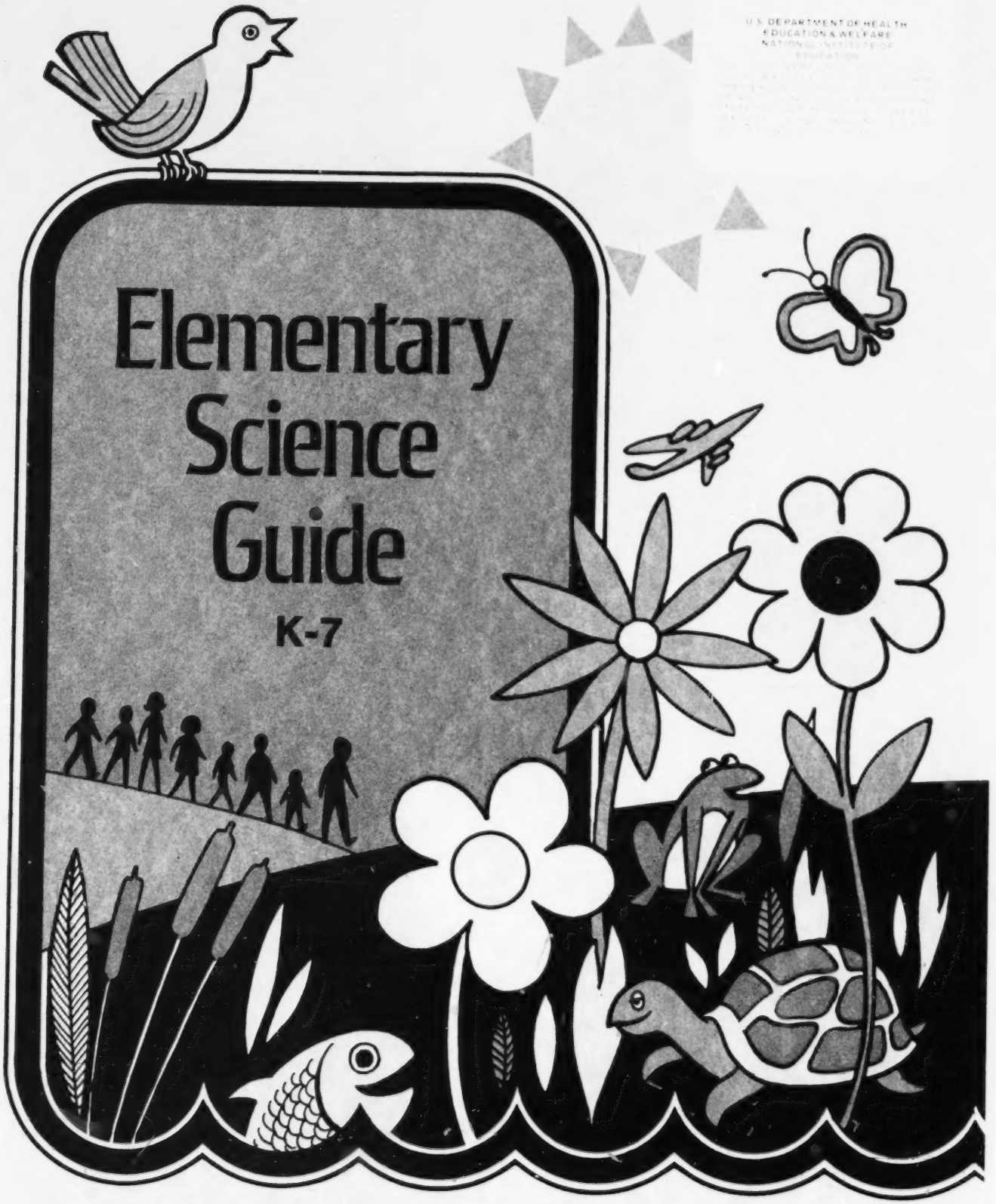

Elementary Science Guide

K-7

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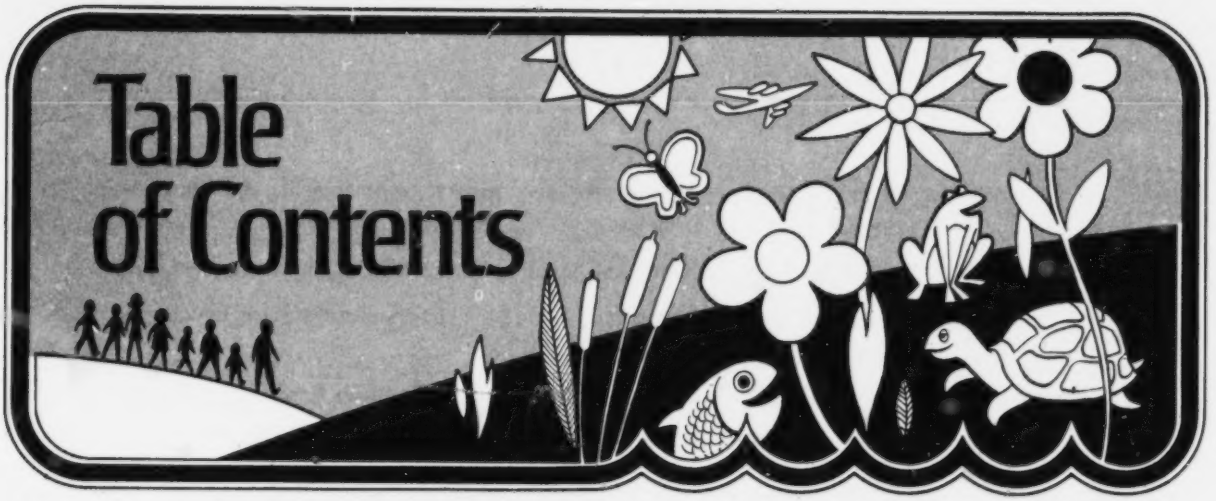

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The Elementary Science Committee was composed of an elementary principal, a supervisor, two college professors, and teachers representing grade levels in the elementary school. Members of the Committee and the staff of the Elementary Education Service met during the summer of 1969 to discuss curriculum needs in the area of elementary science and to suggest direction for committee action. Three two-day work sessions of the entire Committee were held during the 1969-1970 school year and a two-week workshop was conducted at Mary Washington College during the summer of 1970. Additional members were added to the Committee for the summer workshop. The Committee met for a two-day session in 1971 to react to materials and provide further guidance for final stages of preparation.

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ORGANIZATION OF ELEMENTARY SCIENCE GUIDE

This science guide is designed for elementary classroom teachers with the hope that it might provide a new perspective or approach to instruction. The guide has several major sections:

Point-of-View Sets forth a description of science, its role in the curriculum, the role of the teacher, and evaluation procedures which are compatible with a science program based on the active involvement of children in the learning process.

Objectives Describes awarenesses, attitudes, skills, and understandings that should be developed through elementary science.

Process Skills Identifies eleven basic skills necessary for effective "sciencing." A summary chart illustrates the interrelatedness of skills at four stages in elementary school. Teachers can guide skill development of individual children by means of the sequence described.

Planning for Safety Describes safety considerations important in the program.

Conceptual Areas Outlines and classifies the major content of elementary science into nine conceptual areas. Each of the nine areas is divided into five subsections:

I. Living Things
II. Matter and Energy
III. Earth
IV. The Universe
V. Man and Technology

Suggested Bibliography Lists professional books for science in the elementary school.

INTRODUCTION

The Elementary Science Guide K-7 was prepared to assist elementary teachers in planning and implementing an activity-centered, conceptually-based science program. As teachers plan activities for children, provision is made for process skill development as an integral part of learning experiences.

The guide suggests content and activities basic to a program of environmental/ecological education. Various sections examine the interaction of physical and biological forces to form the universe. Understanding of these forces is necessary for citizens in today's world.

Appreciation is expressed to the committee of teachers, elementary principals, supervisors, college personnel, and staff members of the State Department of Education, which worked to prepare this guide. Appreciation is also expressed to other teachers, principals, and supervisors who joined members of the committee in the summer workshop to prepare additional material.

WOODROW W. WILKERSON
Superintendent of Public Instruction

Point-of-View

SCIENCE is a changing, dynamic process developed by man for the purpose of learning about the universe, finding answers to the unknown, validating concepts, and explaining natural and man-made phenomena. Man has always engaged in efforts to understand, to modify, and to live in harmony with the forces that shape the universe in which he lives.

The increase in man's understanding of the complexities of the natural world makes it more important than ever that science be a planned and integral part of the elementary school curriculum. For the elementary child, science provides a method for looking at the universe and stimulates a spirit of inquiry and wonder. Children must have an understanding and appreciation of the interrelationship of the biological and physical forces of the universe. With greater understanding of these forces, values that insure the appropriate use of scientific knowledge and skill are developed.

Curiosity is a universal characteristic of children. The quest for answers may be more evident in some children than in others, but should be encouraged in all. Appropriate activities and resources should enable children to pursue interests aroused by this drive for learning.

Children learn through all of the senses. They look, feel, taste, smell, push, pull, and listen as they explore and investigate their environment. Science is recognized as a dynamic, on-going, and ever-changing process as children are involved in multi-sensory activities in experimentation, discovery, and research.

General objectives for the elementary science program are based on what is known about children and the learning process. These objectives take into account the realities of today and the hopes for the future. The elementary science program should enable children to:

- . . . develop attitudes and values which in daily practice assure a quality environment
- . . . develop skills needed to seek and evaluate information
- . . . use experimentation, discovery, and research with a variety of materials to find answers to questions
- . . . develop concepts which are formulated upon basic scientific knowledge.
- . . . relate the contribution of science to the improvement of life.

Activities of the science program promote growth of skills needed to recognize problems and their possible solutions. Through application of these skills in daily living, children acquire information that helps to develop understanding of the universe—from atoms to stars, from microscopic life to man.

The teacher guides children in making meaningful and useful the information discovered in solving problems, in answering questions, and in exploring the unknown. In so doing, the teacher stimulates and develops the natural inquisitiveness of all children. The effective teacher:

- . . . is enthusiastic and learns with children
- . . . is sensitive to and accepts the individuality of children
- . . . is supportive in relationships with children
- . . . plans with children, individually and in groups
- . . . encourages intelligent responsibility, initiative, curiosity, and self-reliance
- . . . asks questions which are open-ended, and lead to discovery
- . . . demonstrates and recognizes critical thinking
- . . . employs a variety of instructional procedures
- . . . seeks and makes available a variety of materials and resources in and out of the classroom
- . . . interrelates aspects of the curriculum
- . . . uses a variety of evaluative procedures.

Evaluation is a continuous process used to assess all aspects of a child's behavior. Varied evaluative procedures are necessary to cover adequately the wide range of attitudes, skills, and understandings gained by children. Each child is guided to assess progress toward achieving his own objectives and is helped to identify areas for further study. The growth of each child in the ability to recognize and solve problems, to combine facts into broad meaningful concepts, and to respect the total environment should be considered in any evaluation.

Evaluation is also a means of determining the effectiveness of the program. A teacher evaluates materials and teaching procedures in terms of objectives for a given group of children and for individuals within the group. Evaluative techniques may include teacher observations and tests of various types, as well as evaluation of child-developed diagrams, charts, experiments, reports, oral explanations, and illustrations. Viewed in this light, evaluation is more than measurement of achievement; it is an essential part of the teaching-learning process.

OBJECTIVES FOR SCIENCE

OBJECTIVES for elementary science have been stated in this guide in terms of awarenesses, attitudes, skills, and understandings needed to live in harmony with the natural world, and to direct activities to enhance rather than imperil natural conditions.

Experiences in science help the elementary child develop:

1) *Awareness of:*
   a. himself in relationship to the universe
   b. man's attempt to explain natural phenomena
   c. interrelated aspects of the environment
   d. orderliness of the universe
   e. differences between fact and opinion
   f. reliable sources of information and data
   g. increasing scientific knowledge
   h. influences of scientific knowledge on life
   i. safety in daily living

2) *Attitudes of:*
   a. open-mindedness
   b. respect for the opinion of others
   c. acceptance of judgment based on known facts rather than superstitions
   d. curiosity
   e. initiative
   f. self-direction growing out of self-confidence, self-discipline, and self-evaluation
   g. responsibility as a citizen in a technological society
   h. willingness to use unanticipated results of experiments or experiences as a basis for further learning

3) *Skill in:*
   a. utilizing basic processes of observing, classifying, inferring, communicating, predicting, measuring, interpreting data, questioning and hypothesizing, experimenting, constructing and interpreting models, and making working definitions for inquiry and problem solving
   b. critical thinking
   c. effective utilization of materials and equipment
   d. cooperative work with students and teachers

4) *Understanding of:*
   a. concepts of adaptation, change, equilibrium, interrelationships, organization, motion, space, time, and variety
   b. application of scientific knowledge in daily living
   c. implications and responsibilities involved in use of natural resources
   d. relationship of science to other content areas.

PROCESS SKILLS OF SCIENCE

THE process skills of science are the skills necessary for effective "sciencing", and are used by the child to gather information, thus enabling him to build concepts about the world in which he lives. Through this skill development the child builds proficiency in locating, organizing, recording, transmitting, and evaluating information, and acquires a means of refining his thinking.

Eleven skills are described in this guide. The sequential development for each skill has been grouped into four broad stages to serve as indicators for teachers in planning. Process skill development should be an integral part of science activities for children.

Once a skill level has been developed, it will be used as needed in the child's experience and activities. These skills continue to be emphasized at succeeding levels, but in increasingly more complex situations. This strengthens the child's ability to apply the skill and helps him develop readiness for the more complex process skills. Just as development from simple to complex is evident in skill sequence, skill interrelatedness is evident in scope. A particular activity by the children will frequently serve for development of more than one process skill.

SKILL / LEVEL	OBSERVING	CLASSIFYING	COMMUNICATING	MEASURING	INFERRING
SKILL	Observing involves using one or more of the senses in a personal experience of environmental preception. This skill is employed in every phase of daily living. When direct observation is inadequate or impossible, indirect methods are used. Observations may be influenced by the background and previous experiences of the observer.	Classifying involves arranging or distributing objects or events according to a method or system. The process of classifying is based on observing relationships which exist between objects or events.	Communicating involves transmitting data from multisensory observations. Inferences, predictions, and other types of information, ideas, or explanations are communicated by various types of media. Accumulated data may be recorded for accuracy of communication.	Measuring involves developing a comparison or quantative description of such properties as length, area, volume, weight, temperature, or pressure. Both standard and nonstandard units are used in the development of the skill.	Inferring involves suggesting explanations, reasons, or causes for events which have occurred. Direct observation of the event may or may not have been made. Explanations may be developed after observations of related events. Inferences, even though based on judgment and evaluation, are not always valid interpretations of what really occurred. Further observations may be required to establish the validity of the inference and may lead to additional inferences. Inferring requires that an individual think and reason about what has occurred, while predicting involves suggesting what may occur in the future.
K-2 BEGINNING ELEMENTARY	Identifies physical properties of objects by direct observation. Makes observations from different positions or locations. Moves the object being observed for a different perspective.	Groups objects on the basis of observed likenesses and differences. Groups familiar objects on the basis of use (things to wear, to play with, and to write with.) Groups a set of objects into subsets based on a single characteristic.	Describes an observation verbally or pictorially. Gives a verbal description of an object so that another person is able to recognize the object.	Fits objects into matching forms. Orders concrete objects by length or weight. Uses non-standard units of measure such as pencils or shoes.	Makes inferences about everyday experiences. Recognizes that observation is the basis for inference.
2-4 EARLY ELEMENTARY	Uses instruments such as hand lens thermometer, and spring balance as extensions of senses. Differentiates actual observation from personal interpretation.	Groups and regroups a set of objects into subsets according to the characteristic under consideration. Groups a set of objects into subsets on the basis of two characteristics.	Records data pertinent to the topic being considered. Constructs graphs to represent data collected in an activity. Describes the conditions which may have influenced an observation and relates these conditions to the information acquired.	Identifies objects as one-dimensional, two-dimensional, or three-dimensional. Selects appropriate tool for measuring various physical properties of objects. Uses standard units of measure in English and metric systems. Measures force using tools such as a spring balance.	Distinguishes between observations and inferences. Develops an inference based upon previous observations. Recognizes that two people may make different inferences from the same observation.
4-6 MIDDLE ELEMENTARY	Observes repeatedly to accumulate sufficient evidence upon which to base an inference. Uses standard measures for carefully defined observations. Observes a series of events over a period of time and orders them chronologically.	Organizes data into predetermined categories. Classifies data from a series of observations to indicate frequency.	Records events in sequence. Records observations according to a system developed for a specific problem under study.	Uses formulas to generalize methods of measuring ($A = l \times w$; $V = l \times w \times h$). Uses approximate measures properly. Estimates measures of distance, area, volume, weight (mass), time, temperature, and speed.	States several possible inferences from a group of related observations. Separates observations which support inferences from those which do not.
6-7 UPPER ELEMENTARY	Recognizes cause and effect relationships after observing related events.	Classifies data from observations as to relevancy in a particular investigation or situation.	Uses various types of media to obtain and transmit information.	Uses various techniques such as triangulation or water displacement to measure length, area, or volume when a tool may not be applied in direct measurement. Orders objects in one-dimension (linear), two-dimensions (area), and three-dimensions (volume). Uses tools of measurement appropriately. Uses tools to make precise measurements.	Makes additional observations which can be used to test an inference. Recognizes limitations of inferences. Recognizes that inferences may need to be changed after additional observations.

PREDICTING	EXPERIMENTING	CONSTRUCTING AND INTERPRETING MODELS	QUESTIONING AND HYPOTHESIZING	INTERPRETING DATA	MAKING WORKING DEFINITIONS
Predicting involves suggesting a possible result or outcome on the basis of information acquired in one or more observations. Predictions may be made based on inferences from observations. The accuracy of a prediction is strongly affected by the adequacy of the observation.	Experimenting involves testing a hypothesis under controlled conditions in which variables are limited. Procedures to gather data are developed prior to conducting the experiment. Some experiments are based largely on observation but more complex experiments require application of many other skills.	Constructing models involves the building of a mental, physical, or verbal representation of an idea, object, or event as a basis for explanation and interpretation. Models may be used to communicate information, demonstrate the interrelatedness of subjects, or express abstract ideas.	Questions arise from data obtained in observations. Answering questions or solving problems requires application of other process skills. Developing hypotheses requires that a question, and the predictions or inferences related to the question, be stated in a manner that can be tested in a controlled experiment. If a question or hypothesis gives rise to other questions and hypotheses, each must be tested individually.	Interpreting data is a complex skill involving aspects of other skills including observing, classifying, predicting, inferring, and communicating. This process develops skill in selecting data which is meaningful, useful, and appropriate to the question under study. Interpretations may be revised when additional data are obtained.	Working definitions are based upon actual experiences in which a child has been involved. Activities which produce observable results are required in order to make working definitions. This type of definition limits the meaning of a term to **what is done** and **what is observed.** In some aspects of science, a child may gain meaning from descriptions of observations. The general description tells **what is observed** but lacks the **what is done** aspect of the working definition. (For example: General Description —A dry cell contains stored chemical energy. Working Definition—A dry cell when properly connected with two wires and a light bulb will cause the bulb to glow.)
Makes predictions based on evidence from observations of everyday occurrences. Differentiates between guessing in which there is little or no evidence and predicting which is based upon evidence from observations.	Manipulates equipment changes position to obtain different perspectives for observation. Performs simple, short-term activities to answer some questions.	Recognizes certain familiar objects (dolls, pictures, globes.) as models of real objects.	Develops questions concerning observations, inferences, and predictions.		
Records observations of an event over a period of time and uses recorded data to predict the next occurrence of that event. Makes predictions on the basis of recorded data.	Conducts simple experiments and records pertinent observations.	Develops pictures, stories, charts, graphs, or diagrams to express ideas. Develops three-dimensional models.	States difference between questions and problems. Selects observations which assist in answering questions.	Selects data useful to answer questions under consideration.	Distinguishes between a general description and a working definition.
Uses data from graphs to make a prediction. Uses additional observations to modify predictions.	Identifies constants and variables in an experiment. Makes observations and analyzes data to arrive at a conclusion.	Interprets models and makes inferences. Uses two or more models to explain related events.	Distinguishes between opinion, fact, and hypothesis. Constructs questions which can be answered through accumulation and interpretations of data.	Refines collected data to exclude irrelevant material. Distinguishes between data obtained by direct observation, and ideas obtained by interpretations of the data. Uses collected data to make an inference or prediction.	Selects from several observations and experiences data useful in stating a working definition. Develops alternative definitions for the same word based upon observation and experience under different conditions.
Uses quantitative measurements to make predictions more accurate. Suggests the outcome of future observations based on inferences proposed and tested.	Designs and conducts controlled experiments to test a hypothesis or answer a question. States limitations of observations, experiments, inferences and predictions used in answering questions or testing hypotheses.	Uses measurements to develop models to scale. Identifies limitations of models.	Constructs questions or hypotheses which can be evaluated by observation, or inference. Designs experiments with a control and variable to test questions or hypotheses.	Communicates inference or prediction with the supporting data.	Refines working definitions to include data necessary for clarity in communication.

PLANNING FOR SAFETY

THE success of an activity-centered elementary science program is contingent upon many factors including adequate planning. In addition to general planning necessary for development of a sequential program which includes process skills and concepts and meets the needs and interests of pupils, specific plans must be made for safety in all activities. Unfamiliar activities should be performed by the teacher before being introduced to children. This will allow the teacher to:

- know what to expect
- estimate time needed
- anticipate children's questions
- check equipment and materials
- acquire needed quantity of equipment and materials
- modify procedures to suit children's abilities
- become cognizant of safety considerations.

General Safety Considerations:

1. Procedures and safety considerations should be reviewed before beginning any activity.
2. To avoid problems generated by haste, sufficient time should be allotted for children to perform activities.
3. When groups of children are working with limited amounts of equipment, the group should be small enough to prevent accidents.
4. When working with equipment and materials with special hazards, small groups should work under constant supervision.
5. Equipment should be moved through hallways at uncrowded times, and in suitable containers or on equipment carts to avoid breakage.
6. Use of unfamiliar equipment by children, including saws and knives, may require special instructions.
7. Equipment should be inspected for flaws and all defects repaired or equipment replaced.
8. Heavy equipment should be stored on lower shelves.
9. All accidents should be reported to school authorities according to procedures established by the school.
10. Application of safety in everyday situations should be correlated with the science program.

Safety with Heat and Electricity:

1. Any piece of equipment (including a projector) which is hot should not be moved until cool.
2. Hot plates with smooth surfaces rather than coils are preferable to other heating methods.
3. All heat sources should be observed carefully until cool.
4. If open flame heating devices (candles, propane or bunsen burners, or alcohol lamps) are used, caution is needed regarding loose clothing and long hair.

Safety with Plants and Animals:

1. Animals brought into the class should be free of disease and, if mammals, inoculated for rabies.
2. Poisonous animals should be prohibited.
3. Plans should be made for food, housing, and general comfort before an animal is brought into the room.
4. Handling of animals should be limited to that which is necessary, such as in cleaning of quarters, or observing in an activity.
5. Children should wash their hands after handling animals.
6. Cleaning of animal containers should be done on a regular basis with wastes disposed of properly.
7. Children should be taught respect for the animals as exhibited in proper care and lack of teasing.
8. Plants which might produce allergic reactions should be excluded from study.
9. Bacteria cultures should be undertaken only if sterile techniques can be employed and the teacher is thoroughly familiar with microbiological procedures.
10. Field studies should include developing awareness of poisonous plants and animals, and general safety procedures.

Safety with Chemicals:

1. Containers should be properly labeled.
2. Random mixing of chemicals should be prohibited.
3. Volatile or flammable liquids must be used with caution near heat sources.
4. Dangerous chemicals should be used only under teacher supervision.
5. Emphasis must be given to the fact that use of chemicals requires that directions for an activity be followed precisely.

Eye Protection:

Any activity in which there is danger to the eyes shall be performed while wearing eye protective devices. Such activities would include:

a. heating substances
b. chipping rocks
c. using caustic materials
d. complying with other locally-established safety regulations.

CONCEPTUAL AREAS OF ELEMENTARY SCIENCE

IN planning the organization for the Elementary Science Guide, the content of science was classified into nine conceptual areas:

ADAPTATION
CHANGE
EQUILIBRIUM
INTERRELATIONSHIPS
MOTION
ORGANIZATION
SPACE
TIME
VARIETY

These nine conceptual areas are interrelated and overlapping and serve as a perspective for science content which is new for many teachers. Because of this interrelatedness, cross references to other sections are given throughout the guide.

In order to give some structure and consistency to the organization of content within the conceptual areas, each was divided into five subsections. The five subsections emphasize the relationship of the conceptual area to:

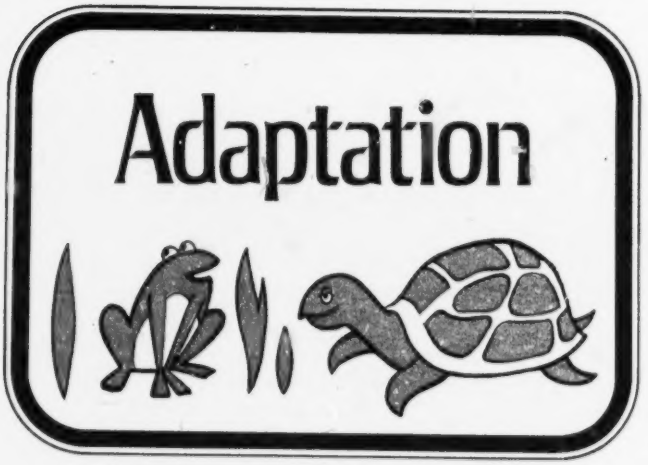
I. Living Things
II. Matter and Energy
III. Earth
IV. The Universe
V. Man and Technology

Each of the subsections outlines appropriate content *written in language for teachers* followed by suggested *activities for children*. Both the content and activities must be viewed as a beginning of what might be included, rather than a complete coverage of the topic and activities. Teachers will see opportunities to modify and simplify suggestions as well as opportunities to extend and enrich them.

The conceptual areas may be thought of as themes of science separated into threads which when interwoven become the fabric of the discipline. The social implications of science and scientific knowledge serve as the color for this fabric of science; for only as science serves humanity is its knowledge and skill important.

An effective science program helps to produce a citizenry skilled in appropriate decision making, and thus capable of meeting the needs of today, the challenges of tomorrow, and the unknowns of the future with an attitude of confidence, a sense of responsibility, and a desire for knowledge which serves humanity.

Adaptation



ADAPTATION is the process of change in the characteristics of plants or animals which results from the interaction with the environment over a period of time. It is a process over which an organism has no control. Because the process of change is very slow, man observes the end products of the process. These changes are genetic alterations affecting the function or structure of organisms which enable them to survive and reproduce. If an organism adapts to changing external conditions, it will survive and produce offspring which are likely to be equipped to survive in those same conditions. Organisms which are unable to meet their life needs, or fail to adapt, do not survive.

Some types of adapative functions such as thickening or thinning of an animal's fur are related to seasonal changes. Other adaptive functions may be related to withstanding daily temperature extremes such as found in the desert. Body organs of higher animals are adapted for their functions such as gills of fish or the pouch of an opossum.

Adaptations of some organisms are frequently so specialized as to limit the habitat. For example, many pond organisms are adapted to the quiet pond environment, but not to life in a swiftly flowing mountain stream. Defense mechanisms and protective coloration are other adaptations which enable some species to survive.

ADAPTATION

I. Living things are adapted to their natural environment and may adapt to changes in the environment. Adaptation in structure and function has enabled organisms to meet life needs.

A. Special body structures enable animals to carry on life processes and survive within the limits of the environment.

1. Special body structures enable animals to move from place to place.

a. Aquatic animals are supported by water, and have specialized parts to propel them.

b. The appendages of most land animals are designed for support and movement of the body.

1.) Some appendages have a specialized "foot" at the end.

2.) Other appendages such as wings may be specialized for movement through air.

Observe and compare methods of locomotion of: rabbit—hopping horse—walking, galloping squirrel—climbing bird—flying duck—swimming fish—swimming snake—crawling ostrich—running
Name the specialized body structures used by each of the above animals in moving from place to place.
Note how man has invented special tools resembling specialized body parts of animals to aid in his locomotion and the movement of his machines (flippers for skin diving, wings of airplanes, snowshoes.)
Use pictures, films, and filmstrips to illustrate the diverse means of moving from place to place.
Take a field trip to a farm to observe animal movement.
Make a chart displaying pictures of special body structures which make movement possible.
Study feet of different animals and discuss the specialized features in relation to the place the animal lives, the way it moves, and the kind of food it eats.
Refer to Motion I-A.

2. Special body structures enable animals to obtain and consume food.

a. In some animals, specialized structures serve the dual purpose of movement and food-getting.

b. Often the in-take of the digestive system is specialized into a "mouth" which in turn may have specialized parts.

Study pictures of the mouth parts of carnivorous (meat eating), herbivorous (plant eating), and omnivorous (variety eating) animals. Note teeth. Classify animals according to their food type.
Compare the beaks of various birds, such as the woodpecker, robin, hummingbird, pelican, hawk, and sparrow. Relate beak type to type of food consumed.
Investigate the use of prehensile tails by New World monkeys and the oppossum.

3. Special body structures enable animals to defend themselves.

a. Some forms of defense are in part associated with seasonal environmental changes:

1.) thickening or thinning of fur;

2.) changing color of fur.

Compare the body covering of animals that normally live in the frigid, temperate, and torrid zones.
Examine the fur of a pet dog or cat in the fall and spring and note changes.
Read about animals having fur which changes color with the seasons. Discuss reasons why this change may be beneficial to the animal.

b. Other defense forms are in part associated with predators:

1.) escaping enemies by fleeing;

2.) engaging in combat;

3.) being inconspicuous to enemies due to coloration, or patterning of markings;

4.) having a skin or similar covering which offers protection (armadillo, turtle, porcupine);

5.) other defense adaptations as exhibited

by animals such as the skunk (odor), and the oppossum (feigning death).

Investigate the cooperation of some animals in protecting the group, or in attacking other animals.
Graph the speeds of various animals in obtaining food or escaping enemies.
Read about and discuss the camouflage of some snakes, deer, insects, quail, and frogs.

4. Special body structures enable animals to reproduce.
   a. The nature of the reproductive process and associated body structures is related to the nature of the environment in which the animals live and reproduce.
   b. The number of off-spring produced is directly related to the problems of survival and degree of parental care required.
   c. Factors such as external fertilization, jelly-like egg, lack of parental care, and water site of egg deposition interact to produce a high degree of egg and/or youth mortality; thus, many thousands of eggs are produced.
   d. Factors such as internal fertilization, internal embryonic development, and high degree of parental care interact to produce a low degree of infant mortality; thus, fewer eggs are produced.

Show filmstrips or films about the development of a chicken embryo.
Obtain frog eggs, place in aquarium and watch development.
Obtain praying mantis cocoons and observe development.
Form class committees and obtain information to fill in this chart. (Sections 4c and d of the outline give clues to some of the ideas to be filled in). Use reference materials to find information. Look for the generalizations about a group of vertebrates. The exceptions to the rule can be covered in the section Unusual Features or Creatures. Examine closely the relationship between the characteristics listed on the left. For example: Does the fact that reptiles lay eggs with leathery shells, as opposed to the jelly-like eggs of fish and amphibians, mean that reptiles may be found farther from water?

	Fish	Amphibians	Reptiles	Birds	Mammals	Other Animal Groups
Fertilization of Egg						
Characteristics of Egg						
Site of Egg Deposition						
Food Supply for Developing Embryo						
Number of Eggs Produced						
Degree of Parental Care						
Number of Young Surviving to Age of Reproduction						
Habitat						
Body Temperature						
Skin or Outer Covering						
Unusual Features or Creatures						

5. Special body structures enable animals to obtain oxygen and release carbon dioxide.
   a. Gills in fish;
   b. Lungs in reptiles, amphibians, birds, and mammals;
   c. Spiracles in insects.

Observe fish in the aquarium.
Use magnifying glass to observe spiracles in insects.

6. Special body structures enable animals to communicate.
   a. Specific sensory organs enable animals to receive and respond to stimuli from the environment.
   b. The ability to communicate is more evident

in some animals (such as mammals) than in others.

Compare the ears of various animals. Compare the eyes of various animals. Note differences in size, shape, and location.

Observe sounds made by different animals. Note differences. Try to identify animals by sounds.

Read about communication among social insects such as bees and ants.

c. Stimuli from the environment may cause animals to respond in characteristic behavioral patterns in order to survive.

1.) Hibernation/estivation

2.) Migration

3.) Seeking shelter

Identify various animals of interest to the class. Determine which ones hibernate or migrate in response to environmental changes and change of food supply. Also determine which animals seek shelter or build homes of various types. Classify the animals into appropriate groups as mentioned above.

7. Some animals are structurally adapted to insure survival through a social order in a colony or group.

Study animals which live in groups such as ants, bees, and lions.

Establish an ant colony and maintain it for a period of time.

B. Special body structures and functions enable plants to carry on life processes and survive within limits of the environment.

1. The lack of special adaptations inhibits movement of plants from place to place, but movement of plants is identified as the interaction of:

a. Phototropism

Use two potted platns of similar size to demonstrate the effect of sunlight on a plant. Cover one plant with a light-proof cover. Provide air and water for the covered plant. Allow the other plant to have sunlight, air, and water. Record growth and other reactions over a period of time. Compare results.

Place a plant on the window sill or toward a source of light. Water as needed. After several days note that the leaves are turned toward the light. Turn the plant 180°. After several days observe the direction the leaves are turned.

b. Geotropism

Plant some seeds in a jar so that the seeds are visible through the glass. (Quick growing seeds include: radishs, beans, zinnias, marigolds, and sunflowers.) As the seeds germinate note the direction of growth of the roots and stems. Put a top on the jar and lay it on its side for several days. Note the response of the roots and stems of the germinating seeds.

c. Hydrotropism

Remove one side from a half-gallon waxed milk carton, and seal the pour spout tightly. Cut out a rectangular window from an adjacent side leaving a one-inch border. Use waterproof tape to attach a piece of glass or heavy plastic to the window. Make several drainage holes in the bottom of the carton, line with rocks, and fill with soil. Place the plant box in a shallow pan to catch water. Plant several lima bean seeds in the soil at one end of the carton near the window. Observe the germination of the seeds through the window. Allow the germination of plants to occur and water regularly until plants are about two-inches tall and have several leaves. Then begin to water the soil at the end of the carton opposite the end where the plants are. Water at this opposite end for several days. Note reactions of roots after seven to fourteen days.

2. As a result of special adaptations, plants obtain food for nourishment.

a. Green plants are adapted to take carbon dioxide and water from the environment and to produce food (in the presence of sunlight) while releasing water and oxygen as by-products.

Obtain elodea, a common water plant, from an aquarium or supplier. Examine a leaf under the microscope. The green bodies seen in the cells are chloroplasts which contain the chlorophyll.

Extract chlorophyll from a leaf (raw spinach or geranium) by boiling it in water for several minutes to soften the cell walls (cellulose). Since ALCOHOL IS FLAMMABLE, it is necessary to place a beaker or heat-proof jar containing the leaf and some rubbing alcohol in a large pan containing water. Heat the water to boiling on a hot plate and allow the leaf to steep in the hot alcohol for ten to fifteen minutes. Remove the leaf with tweezers or tongs. (The alcohol should be green with the extracted chlorophyll.) Rinse the leaf with hot water. Place the leaf in a saucer or on a paper towel. Place a few drops of tincture of iodine on the leaf. The blue-black color indicates the presence of starch in the leaf. (The plant stores the food (glucose) which it produces as starch.) This activity produces best results if the plant has been exposed to several hours of sunlight before removing the leaves. Why?

Cover the top and bottom surfaces of the leaf of a healthy plant with a thin layer of petroleum jelly. Allow the plant to have normal water and sunshine for several days. Compare the treated leaf with untreated ones. Explain the result. (The petroleum jelly covered the stomates preventing the exchange of gasses with the environment.)

Cover one leaf on a healthy plant with aluminum foil or some other light-proof covering. Allow the plant to have normal sunlight and water for several days. Remove the cover from the leaf and compare it with others. Explain the results.

Place an elodea plant under an inverted clear plastic or glass funnel in an aquarium. Place a test tube filled with water over the funnel stem. Allow several days to pass being sure the plant has plenty of sunlight. Note the change in the water level of the test tube. After most of the water has been displaced (by oxygen), remove the test tube. Test for the presence of oxygen by placing a glowing wood splint in the test tube. Explain the result. (The presence of oxygen will cause the glowing splint to glow more brightly or briefly burst into flame.)

b. Non-green plants may be partially or wholly parasitic, and are adapted to obtain food from host plants or decaying material.

Study samples of various types of molded food.

Find the mycelium of mushrooms and note the decaying leaves or high humus content of the soil in which they grow.

Locate and observe fungi growing on trees or stumps.

3. Protection in plants is a passive process due to limited mobility. Special adaptations for protection include:
   a. Thorns

Examine thorns on various kinds of plants. Discuss how the thorns protect the plant.

   b. Bark

Examine the bark of various trees. Note that the bark is usually quite distinctive and can be used as a clue to the type of tree during winter months when deciduous trees have no leaves. Discuss how bark protects a tree.

   c. Thick waxy layer on leaves

Study leaves from many different plants. Explore the relationship between leaf shedding and thickness of waxy layer.

   d. Fleshy stems

Cactus plants have thick fleshy stems. How do these stems protect the desert-dwelling cactus plants?

   e. Shedding of leaves

Hypothesize why plants shed their leaves. Read resource materials to find evidence to support or disprove your hypothesis.

   f. Specialized root systems

Bring examples of different kinds of roots to class and compare as to size and shape.

Examine the root systems of several different plants and young trees noting tap and hair roots.

4. Special body structures enable plants to reproduce.
   a. Non-flowering plants reproduce primarily by:

Study the various types of non-flowering plants such as bacteria, algae, fungi (molds, mildews, yeasts, mushrooms, lichens), mosses, liverworts, and ferns. Find samples of these plants on a field trip.

1.) Cell division, or budding

Grow some yeast cells by adding a quarter yeast cake or a package of dried yeast to a glass of warm water containing a teaspoon of dissolved sugar. Allow the tumbler to stand in a warm place for about 24 hours. Place a drop of the yeast culture on a slide and examine it under the microscope. Sketch what is seen. Are different shapes of cells seen?

2.) Spore production in which cells capable of growing into the plant are encased in a hard shell.

Collect several mushrooms and examine the parts. Cut off the stalk and place three or four toothpicks at the edge of the cap so the mushroom and toothpicks look like a stool. If the spores on the gills appear dark use light paper, and vice-versa. Coat the appropriate colored paper with egg white. Place the mushroom with the toothpicks over the coated paper and cover with a wide-mouth jar or deep bowl. After a day or two remove the jar and the mushroom carefully to find a spore print.
Examine the spores of mushrooms and puffballs under a microscope. Examine bread mold with a magnifying glass to locate site of spore production.
Place a piece of the bread mold on a glass slide and add a drop of diluted blue ink. Examine with a microscope to locate site of spore production.

b. Flowering plants produce seeds which contain the plant embryo and a food supply for the embryo.

Dissect a flower and display ovary containing ovules or beginnings of seeds. Mount and label parts.

1.) Some flowering plants may also reproduce vegetatively in which one plant part is capable of producing a new plant.

Study plants like the strawberry to see how new plants are formed.
On a field trip observe how some root systems sprout and a new plant begins to develop.
Obtain leaves and stems of various plants. Place them in water and see which ones will develop roots.
Grow new plants from pieces of carrot or sweet potato.
Plant the "eyes" on a potato to see if a new plant will grow.

2.) Seeds are an advancement over spores in that the multi-cellular embryo and food supply of the seed more nearly insure survival.

Obtain some lima bean seeds. Soak them in water for several hours to soften the seed. Carefully remove the seed coat. Separate the seed into the two seed leaves. Locate the tiny plant embryo attached to one seed leaf. Study the embryo with a magnifying glass.
Do this same activity with a corn seed. (This plant has only one seed leaf.)

c. Seeds and spores are dispersed by such forces as:

1.) wind

2.) rain or water

3.) insects, birds, mammals

4.) man

5.) gravity

6.) exploding seed or spore case

Gather different types of seeds and explore the different ways seeds are spread.
Make a chart of different types of seeds and the method of dispersal based on observation, inference, or research.

5. Special body structures enable plants to obtain oxygen and release carbon dioxide in the process of respiration.

a. Higher plants have openings in their leaf surfaces called stomates through which gases can pass.

Use a microscope to observe stomates in the leaf of the plant. A leaf from a plant which has soft tender leaves can be rolled between your hands several times to loosen the lower epidermis. Use a razor blade or sharp knife to peel off this lower layer of cells. Mount a small section of the epidermis in water on a glass slide, add a cover slip, and examine with a microscope. Move the slide carefully until a stomate and its surrounding guard cells are found.

Build a model of a cross section of a leaf including the stomates and guard cells.

Refer to Adaptation I-B-2-Activity 3.

b. Some exchange of gases can occur when gases are dissolved in water.

1.) Roots absorb some of these gases with the water.

Place the roots of a plant in colored water. The colored water will be absorbed by the roots and transported throughout the plant.

2.) Aquatic plants absorb and release gases in the water.

Perform activity 5 Adaptation I-B-2 in which oxygen produced by elodea is collected.

C. Adaptations which enable living things to meet life needs may be passed on to successive generations.

1. Most adaptations occur as gradual changes through several generations.

Study the changes which have occurred during the evolution of the horse.

2. Adaptations in structure and function of plants and animals may result from environmental changes.

3. Natural selection occurs when environmental circumstances determine which organisms survive; thus those best adapted to a particular situation are survivors which produce future generations.

4. Man has developed variations in plants and animals by selective breeding.

Study various breeds of dogs, most of which man has developed to suit a particular purpose.

Invite a farmer or county agent to visit the class and discuss various types of crop plants which man has produced.

II. Living things are adapted to their natural environment and may adapt to changes in the environment. Living things may adjust to forces in the environment and develop characteristics which are not genetic adaptations.

A. Several interacting factors composing the abiotic (physical) environment may alter the physical appearance of individual organisms without changing the genetic base of the organisms.

1. Wind

Compare pictures of the same species of plants growing in different environments where high winds may be a factor. (Example: Live oak trees growing by the sea and farther inland.

2. Light intensity

Find plants of the same species growing in shade and sunlight. Assuming the water supply and mineral content of the soil to be similar, can a difference be seen in plant growth and size?

Obtain several plants of the same approximate size. Allow each to have different hours of sunlight. Measure the growth weekly for several weeks and graph the results.

3. Temperature of air, water, or soil

Obtain two plants of similar size. Place one in the refrigerator for a few days. Keep the other in a warm spot but keep it in darkness as the one in the refrigerator. Compare after several days. Alternate the in-the-refrigerator sequence with the out-of-the-refrigerator sequence for several weeks. Compare the two plants. Periodic measurements, if taken, can be graphed for comparison.

4. Chemical content of air, water, or soil.

Invite the county agent or other knowledgeable person to discuss how fertilizers affect the growth of plants, and food supplements affect the growth of animals.

B. Lengths of seasons as well as the ranges of temperature within a season may affect the appearance,

reproductive processes, and life cycles of plants and animals.

Obtain a log on which annual growth rings are visible. Infer which years had conditions favorable for growth as indicated by a thicker ring, and which years were unfavorable as indicated by a thinner ring.

C. Only living matter can adapt.

III. Living things are adapted to their natural environment and may adapt to changes in the environment. Organisms are adapted to a specific environment on Earth.

A. Environments with specific differences become the life space for different organisms.
   1. Organisms adapted to life in a specific habitat are structurally different in various ways from those of another habitat.

Form class committees and have each study a different habitat such as: a tidal zone of the ocean, deep temperate forest, edge of meadow, swift-flowing fresh water stream, or desert. List the characteristics of each habitat and make a chart comparing the characteristics. Select representative plants and animals from each habitat and study the special adaptations which enable them to live under specific conditions.

   2. Land organisms adjust to a wider range of environmental conditions than aquatic organisms.

List conditions to which land organisms must adjust, and compare to those of aquatic organisms.

B. Organisms may react to changes in the environment by adjusting, adapting, or becoming extinct.
   1. Some changes in the environment are seasonal, and organisms remaining must adjust by reactions such as thickening fur, or shedding leaves.
   2. Other organisms unable to adjust to seasonal change or unable to obtain food after the change may migrate or hibernate.

Study plants and animals of an area to observe their reactions to seasonal changes.

C. Physical or abiotic factors of the environment may affect several species of animals.
   1. Generally those animals living near the equator are more colorful than those living near the poles.

Arrange a display of drawings or pictures of animals from the tropics and the tundra. Discuss the appearance of the animals in relation to the habitat in which they live.

   2. Generally animals from cold regions have shorter, thicker appendages and stockier bodies than tropic dwellers.

Study pictures, films, or filmstrips of polar and tropic animals. Why do polar dwellers have short, thick appendages, and stocky bodies?

D. Life as we know it is dependent upon water which is a basic component of the protoplasm of cells.

Grate a potato and observe the high water content.

Place pieces of celery or an apple on the desk and allow them to dry out.

Investigate various types of dried fruits or dried meat.

IV. Living things are adapted to their natural environment and may adapt to changes in the environment. Life is adapted to environmental conditions in the universe.

A. Wherever life is found, and whatever it is like, it is adapted to its environment.

B. The range of tolerable environmental conditions necessary for life is so narrow that the possibility that life as we know it is found elsewhere in the universe is a question which scientists seek to answer.

Since life as we know it is based on the water composition of cellular protoplasm, how would temperatures outside the range of 0°-100°C (32°-212°F) affect cells?

C. Man in exploring inter-planetary space must make provisions for a suitable environment through life-support systems.

Investigate the various life-support systems necessary for extraterrestrial travel.

V. Living things are adapted to their natural environment and may adapt to changes in the environment. Man must learn to live in harmony with adaptation, and his activities should enhance rather than imperil the natural conditions essential to adaptation.

A. Succession is a process in which there is gradual and continuous replacement of one kind of plant/animal system by another system.

1. A community gradually changes over a period of time until it is recognized as another type of community and the boundary between the old and new communities cannot be marked off in time or in space.

Refer to Equilibrium I-A-3.
Visit a tree farm operated by a commercial concern or State Forest Service to determine how man hastens succession by reforestation.
Outline normal succession in cut-over woodland in eastern United States.

2. The rate at which changes occur in a community may exceed the rate at which organisms can adapt.

Refer to Change I-B.
Read about the organisms which failed to adapt and are now extinct, such as dodo bird and dinosaur.

3. Endangered species may be confined to wildlife refuges, preserves, or other undisturbed areas to prevent their extinction.

List some endangered species and describe man's efforts to preserve them.

4. Wildlife populations have economic, aesthetic, and biological importance.

Refer to Equilibrium I-B and discuss the relationship of various animals in the food chain.

5. National and state forests have been designated as areas where a community of plants and animals live in a relatively undisturbed condition.

Determine the differing purposes of National Parks and National Forests.

B. All living things are continually evolving as a result of adaptation to the changing physical environment.

1. The forms of living things in an area depend upon their life needs and the availability of materials to satisfy those needs.

Select several wild animals and determine the type of food consumed. Based on the food type infer the area where each animal lives. Extend this activity by selecting other factors which determine where an organism lives.
Refer to Change I-A-2, Variety I-B-1 and Interrelationships I-B-1 and 2.

2. Organisms are products of heredity and environment.

Refer to Adaptation I-C; Change I-B; and Organization I-A-1, and I-B.

3. Man is affected by many of the same environmental and hereditary factors which influence other organisms and their populations.

4. Man has altered some environmental and hereditary factors.

Review the needs of living things. How are man's needs similar or different? What means does man employ to meet his needs? Do these means differ in different parts of the world and in different cultures? How? Why?

C. The culture of a group is its learned behavior including customs, habits, attitudes, values, institutions, and other ways of life.

1. The culture of a group may be modified due to changes in life style brought about by changes in technology.

Compare a child's day in contemporary U.S.A., Ancient Greece, a primitive tribe in Africa or South America, and an American Indian or Eskimo tribe in the 1800's.
Interview the "old timers" in the community about their life style as children. What differences are most outstanding between then and now?

2. Man may need contact with the natural world and other living things for:

a. inspiriation which frees his creative spirit;

b. recreation and physical activity;
c. change from the complex social structure and pressures.

Write stories, draw pictures, perform dances, or compose music which expresses feelings about the beauty of the natural world. Why do children enjoy the out-of-doors? Why is a trip to a new place fun and exciting?

3. Human resources include physical and mental abilities, and the knowledge which man has accumulated and classified.

Discuss the activities from which each child receives the most enjoyment. Note the many different activities. Do these activities relate to the child's physical and mental abilities? Are any of the activities preoccupational interests? How will the addition of knowledge contribute to the development of the interest into an occupation or hobby?

ALL matter and energy in the universe are continually changing. Changes in matter involve energy exchanges, and may occur naturally or be caused by man. The melting of ice cream, the burning of a log, or the bursting of a balloon are changes that are easily observed. The process of photosynthesis within a green plant or the development of an embryo in a chicken egg are changes which are usually difficult or impossible to observe directly.

Changes occur at varying rates of speed. Sugar dissolves rapidly in hot water, but many years are required for the weathering of rocks. Some changes occur so slowly that they cannot be observed easily. Changes in climate, for example, may occur so slowly that they may not be observable in a man's lifetime. Periodic changes occur within the solar system, some of which are rapid and some of which are slow.

Earth has changed over millions of years. Man has changed Earth over the centuries. The building of cities, dams, and highways has changed the surface of Earth. Wastes from automobiles, cities, and industry have affected living things as well as the quality of our water, soil, and air.

CHANGE

I. Change is a continuous and inevitable process. Living things change as they grow and develop, as they interact with their surroundings, and as they change their surroundings.

A. Changes occur in living things as they use energy in performing such life activities as growth, movement, respiration, reproduction, and response to stimuli.

1. Living things change within their life span in a cycle of birth, growth, maturation, and death.

a. Some young animals pass through stages in which they do not resemble their parents.

Use a cloth dip net to capture a dragonfly nymph in a pond or lake. Place the nymph in a shallow pan of pond water with some rocks and pond weeds. Add more pond water from time to time. Put a large rock or stick embedded in modeling clay in the pan of water for the nymph to crawl on when it sheds its skin at the time it becomes an adult. Feed the nymph raw hamburger, dead flies, meal worms, small fish, or fairy shrimp. Observe the nymph shed its skin or molt and emerge as an adult dragonfly.

Secure frog eggs during the spring. Place eggs in a container of pond water in which plants are present. Watch development over a period of time. Collect information relative to the changes in the development of eggs into adult frogs.

Look on milkweed plant for caterpillars of monarch butterfly from September 15 to October 1. Place caterpillar in a jar on a branch of milkweed plant. Cover the mouth of the jar with cheese cloth so air can get in. Feed the caterpillar leaves of milkweed plant. (The caterpillar will go into pupa stage about October 1 and emerge about 10 days later.) Look on celery and parsley for black swallowtails. Look on cabbage for cabbage caterpillars and moths.

Pack moist dirt in gallon or half gallon jars. Place tomato or tobacco worms in jar. Feed leaves until the worm burrows into dirt. Prepare several jars in order to dig one out during the metamorphosis. Watch for moth to emerge.

b. Other animals resemble their parents throughout their life cycles.

Have children bring in baby pictures of themselves and talk about how they have changed. Collect pictures of baby and adult animals.

Obtain male and female mice, rats, or hamsters, to keep them in a cage in the classroom. Observe them as the female becomes pregnant, as the young are born, and as the young are cared for.

Observe guppies in an aquarium from day to day. The pregnancies of the females become quite obvious. Observe closely; it may be possible to see the young being born.

Obtain a simple incubater from science center or a science supply house. Hatch a fertilized chicken egg in the incubator and care for the young chick as a pet.

Procure egg-laying fish to keep in the classroom aquarium. Observe the life cycles.

2. Changes in living things may be brought about in response to stimuli from the environment such as:

a. daylight/darkness

Make a class leaf collection when leaves begin changing color in the fall. Note the changes in color and associate the change in color with the kind of tree. (Point out that the colors appear when the leaves stop making chlorophyll.) Demonstrate this by obtaining two plants of the same kind, size, and health. Allow the control plant to stay in the sunlight all day. Keep the other plant in a dark closet for half of the day, or longer if necessary. After a few days observe the yellowish appearance of the leaves that have had less sunlight. (These leaves now have less chlorophyll in them and the yellow pigment in the leaves has begun to show.)

b. weather

Observe birds at a feeding station in the school yard. Keep records of the kinds of birds, their activities, and the weather. Note any unusual activities just before a snowstorm.

c. seasons

Study changes that can be observed in the community throughout the year. These might include records of differences in length of daylight and darkness, in temperature, and in the amount of moisture. Bird migration and the differences in the animal and plant populations also might be observed.

Observe how a potted plant, such as a jonquil, appears to die after blooming. Keep the plant where children can see it begin to show life again at a later time.

Watch a turtle hibernate in a terrarium. Observe pet's spring and winter coats. Watch for birds flying south and returning. Observe squirrels storing nuts for winter. Look under loose bark and leaves for hibernating insects.

Explore the school grounds, home gardens, and nearby farms. List plants which grow at some times of the year but not at other times. Discuss the reasons why many of these plants do not grow during the winter.

Take a field trip and ask children to comment on the leaf coloration. Collect a few leaves and note the different colors. (During October leaves will begin to fall from some deciduous trees. With the coming of cooler weather, less nourishment and water reach the leaves. As a result, the leaves begin to show symptoms of disintegrating chlorophyll allowing other pigments to be visible.) Collect branches of several different kinds of trees and display them in the room. Bring in pictures showing signs of changing seasons. Put pictures on bulletin board next to display of fall leaves.

Select a tree on the playground and observe the seasonal changes that occur. Record observations in a systematic way. Take pictures of the tree each week of the school year. Put the date on the photographs, and arrange the pictures in sequence.

d. overcrowding

Take a field trip to observe the shapes of various trees. Find a tree in a crowded area and sketch or photograph its shape. Find another tree of the same kind in an open area and sketch or photograph its shape. Compare the sketches or photographs.

e. food shortage

Obtain a healthy geranium plant. Cover all its leaves with aluminum foil for several days. (The foil prevents sunlight necessary for photosynthesis from reaching the leaves, thus cutting down the food supply for the plant.) Observe results.

Discuss the role of a weight control diet for a human. (This is a controlled type of food shortage.)

f. water shortage

Keep two or more geranium, coleus, or begonia plants in the classroom without watering them for a few days. Keep the same kind of plants under similar conditions but water them adequately. Compare results.

g. enemies

Find a tree which has had the bark punctured or split by man or insect activity. Note the tissue which has built up around the injured area.

Observe the reactions of animals when an enemy approaches.

h. temperature

Obtain two bean seedlings as close to the same size as possible. Record the size of each plant by measuring height, size of leaves, number of leaves, and other pertinent data. Place one plant in a refrigerator making sure that it is not in a position in which it will freeze. Place the other plant in the classroom where it will be at a normal temperature. Put a box over it so that it too will be deprived of light. Place a thermometer in the soil by each plant. Provide both plants with identical amounts of water. Every few days record the temperatures and measurements. Compare results and draw conclusions concerning the effect of temperature on plant growth.

Place a thermometer in the soil of each of two bean seedlings. Cover each seedling with a box to keep out the light. Partition one box so that a light bulb can be placed in it in such a way as to raise the temperature of the plant but not expose the plant to light. Provide both plants with identical amounts of water. Every few days record the temperature of the seedlings and measure their growth, height, number of leaves, size of leaves, and other data. Compare the plants and determine the effect of temperature on growth. This comparison can be made most vivid by putting the collected data on graphs.

Count cricket chirps for 15 seconds and add 40. The resulting number is equal to the approximate temperature. Experiment and graph the results.

Collect several houseflies and put them into a quart jar. Surround the jar with ice cubes. Note the activity of flies as the air around them begins to get much colder.

B. As physical environments change living things in the environment may need to change or become extinct.
   1. Environmental changes may be sudden and traumatic such as forest fire, flood, or tornado.
      a. In a sudden environmental change the living organisms which have survived may adjust their life style.
      b. Animals may react by migrating, changing diet, or building new home sites.

Invite the local game warden or forest warden to visit the class to discuss these traumatic environmental changes and the responses of the plants and animals.

   2. Environmental changes such as climate, drought, pollution, overpopulation, increase of one life form which consumes or crowds out another, or natural succession in a community may be slow in developing.
      a. Those organisms which do not adjust to the environmental changes may die.
      b. If the environmental changes affect an entire species, and the species cannot adjust in some way, the species may become extinct.

Study the natural succession of an area from an open field to a forest. How does a change in the type of plants found in an area influence the type of animals found in the same area?

Refer to Adaptation V-A, and Equilibrium I-A-3.

Read about fish kills which occur occasionally from pollution of rivers and streams.

      c. According to theories of evolution, living things have changed over long periods of time.
         1.) Some living things have changed in diversity and some in size over the ages.
         2.) Few species have survived through the ages with little or no change.
         3.) Living things have evolved from simpler forms to more complex forms.
         4.) Survival of the fittest means that those organisms best suited to an environment survive to produce offspring.
         5.) Changes in genes produce changes in living things.

Study various references for information about theories of evolution of horse and dog.

Trace an inherited trait that is a family characteristic. For example, one might trace the trait "dimples" or "red hair color." Have children consult their parents and make a "family tree" chart. Indicate by the name of each person on the "tree" whether or not he or she possesses the trait.

Read books to find which animals have changed little through many years.

Refer to Organization I-B-4.

Consult textbooks and references to locate information on the genetic code. Notice that the genetic code is sometimes altered by nature, and that by selective breeding the production of changes in living things can be reproduced. Bring in leaves of clover and look for a four-leaf clover. Bring in pictures of oranges, grapes, blackberries, cattle with long horns, and daffodils.

Then ask:

(1) Why does some clover have four leaves?
(2) Would you prefer eating berries with or without seeds? Oranges?
(3) What characteristic of long-horned cattle would cause you anxiety if you met one?
(4) What color do you expect a daffodil to be?
(5) Are there any animals which are white instead of their normal color? What are they called? Why are they rare in the natural setting? (Albino; easy prey for enemies.)
(6) When in the development of a plant or animal would changes to seedlessness, colorlessness, hornlessness occur?
(7) How is man able to help nature reproduce oddities when they appear in a plant or animal?
(8) When desirable mutations are found, how can they be reproduced? (Grafting, selective breeding)
(9) What qualities would you desire in meat that could result from selective breeding of mutants? (less fat, more white meat)
(10) What quality would you desire in plant foods? (fewer seeds, larger potatoes, improved flavor)

C. Living things cause changes in the environment.

1. As various plants grow and develop they:

a. influence the hydrologic cycle;

Locate two hills or road cuts, one having good plant growth and the other lacking plant growth. How does the presence of plant growth assist in preventing erosion?

Obtain two flower pots, one with a plant in good soil and the other with just soil. Water both moderately. Place a stick in the one with only soil. Cover both pots with a plastic covering and tape the coverings securely around the bottom of the pots. Observe the covered pots for several days. Note the droplets of moisture on the one containing the plant. This water is given off by the plant as a waste product of photosynthesis. Refer to Adaptation I-B-2-a.

b. alter the flow of air;

Locate a row of trees which someone has planted for a windbreak. How do the trees planted in this way serve man's needs?

c. alter the composition of the soil in which they grow;

Invite the county agent or a farmer to visit the class. Discuss why crop rotation is a good practice.

d. are part of the oxygen-carbon dioxide cycle;

Repeat activities relative to photosynthesis which show that the green plant, in this process, takes in carbon dioxide and gives off oxygen. Refer to Adaptation I-B-2-a.

e. take up life-space and interact with other living things in competition for life-space;

Take a field trip to observe plants. Notice sites where one kind of plant is crowding out another. Refer to Change I-A-2-d.

f. provide food and shelter for some animals.

Find a tree which shows evidence that animals live on it. Look for smaller as well as larger animals. Study the activities of the animals.

Prepare a display of plants and plant parts which man uses for food.

Find leaves which show evidence that animals use them for food.

2. As various animals grow and develop they:

a. influence the hydrologic cycle as they interact with plant life through overfeeding or building of shelter;

Find pictures which show the results of animals over-eating and destroying the plant life in an area.

Study the activities of burrowing animals like ants and worms to note how they affect the porosity of the soil.

View a film on dam building activities of beavers. How do these dams and the associated canal system influence water flow in an area?

b. alter the composition of soil as a result of waste deposit;

Study the use of organic waste materials as fertilizer.

c. alter the degree of compaction of soil by trodding or burrowing;

Find a path on the school yard which children use regularly. Study the compactness of soil particles in the path as compared to a site off the path.

Dig in soil for earthworms. How does the soil in which worms are found compare with soil in which no worms are found?

d. are part of the oxygen-carbon dioxide cycle;

Use the classroom aquarium to study the need for balance between animal life and plant life for the oxygen-carbon dioxide exchange.

Prepare a bulletin board display which illustrates the cycle.

e. take up life-space and interact with other living things in competition for life-space.

View films which illustrate animals living in various areas and chasing animals which invade their territory.

Notice a bird chasing other birds off the yard.

3. The environment is changed by living things through natural recycling processes.
   a. Decay of organic matter releases the basic elements into the environment.
   b. Life processes rebuild these basic elements into organic compounds.

Build a compost pile and study the decay of materials in the pile. Use this compost around plants in the schoolyard.
Refer to Change V-A.

II. Change is a continuous and inevitable process. Matter and energy are involved in all changes.

A. Some changes in the properties of matter are reversible, some appear to be irreversible.
   1. A physical change is one in which the identifying properties of a substance remain unchanged.
      a. Changing the state of matter is a physical change.

Put some ice cubes in a pan and allow them to melt. Boil the water in the pan on an electric hot plate. Hold a glass of cold water about a foot above the boiling water. (The liquid water will evaporate into a gas and condense on the glass into a liquid. Since the solid, gas, and liquid are all water, the changes which take place are all physical changes.)

      b. Other physical changes include changing the size or shape of a substance.

Use an electric hot plate to heat a piece of paraffin in the top pan of a double boiler or in a tin can immersed in a pan of water. The paraffin melts. Cool the paraffin and it becomes solid again. (Because the solid and liquid forms are still paraffin, the changes which take place are physical changes.)

   2. A chemical change is one in which a substance is changed into a new substance with new properties.

Put a small amount of sugar into a test tube and heat it over a candle flame. (The sugar will turn black and moisture will form on the side of the tube. Since the sugar has been broken down into new substances a chemical change has taken place.)

      a. Certain chemical changes among simple elements result in complex substances.

Mix equal amounts of powdered sulfur and iron filings in a test tube. Small quantities work best. Hold the test tube with clamps over a heat source being sure the opening of the test tube is pointed away from people. When the two elements are fused together you have created a new substance—iron sulfide. Test with a magnet. (There should be no reaction.) WEAR GOGGLES!!!
Place some cooked egg yolk in a small dish. Put the end of a clean silver spoon into the yolk and leave it for an hour or two. Examine the end of the spoon. Notice the black tarnished area. (The tarnish is silver sulfide.)

      b. Certain chemical changes result when complex substances are taken apart to form simpler substances.

Pour hydrogen peroxide into a glass jar or beaker. Add one teaspoon of manganese dioxide to the jar and place a piece of cardboard over the opening. Notice the bubbling which occurs. When the bubbling slows down, place a glowing wooden splint into the jar and observe the reaction. (The splint will burst into flame which indicates the presence of oxygen which was produced by this reaction.)

      c. Countless chemical changes continuously occur in living organisms.

Repeat activities relative to photosynthesis in Adaptation I-B-2-a.
Obtain several unsalted soda crackers. Chew them thoroughly but do not swallow them. Allow plenty of saliva to mix with the chewed crackers. Notice the sweet taste which becomes stronger. (This is a chemical change in which the starch in the cracker is chemically changed into sugars.)

B. Energy can be changed into matter and matter can be changed into energy.
   1. In nuclear reactions, a loss of matter results in a gain of energy.
   2. The sum of matter and energy remains constant.

Show films on atomic energy to illustrate changes of matter into energy.
Contact the electric company about information on nuclear power stations.

C. Energy can be changed from one form to another.
   1. Energy can do work as it changes from one form to another.
   2. Electricity is converted into usable energy which includes heat energy, light energy, mechanical energy, and sound energy.

Draw or cut pictures from old magazines which show examples of devices capable of changing energy from one form to another. Label or symbolically indicate what kind of energy goes into each device, what kind comes out, and what work can be accomplished by the device.

Refer to Variety II-B.

Examine several hand tools, electrical appliances, and other devices. Discuss the types of energy which are produced by each. (For example, an electric iron converts electrical energy to heat energy. An electric light converts electrical energy to heat and light energy.)

   3. Man's ideas about energy may change as he continues to study.

D. All changes in the properties of matter result in a gain or loss of energy.
   1. Energy is involved in all chemical and physical changes in matter.
   2. A change in the state of matter is determined by a change in molecular motion.
      a. Heat energy must be absorbed to change a substance from a solid to a liquid, or a liquid to a gas.
      b. Heat energy must be lost to change a substance from a gas to a liquid, or a liquid to a solid.

Make gelatin at school and watch the changes in the states of matter as it "sets." Warm the gelatin and record the changes, then cool it again.

      c. The addition or loss of heat energy increases or decreases molecular motion.

Obtain several substances or materials which have characteristic odors such as onions, vinegar, powdered and flavored gelatin, and perfume. Divide the materials so there are two samples of each in closed containers. Place one set of samples in the refrigerator and the other in a warm area. After several hours compare the intensity of the odors of the "cool set" and the "warm set." Which set is easier to smell? (The warmer set should have a higher degree of molecular activity and thus have more molecules escaping to be observed as the characteristic odor.)

Refer to Motion II-A.

Conduct low-temperature research to point out change of properties in matter. To obtain low temperatures, do the following *USING EXTREME CAUTION:*

Place about two inches of acetone in a clean empty tin can. (A bottle of acetone may be obtained from a drug store.)

Add small bits of dry ice to the acetone in the can. *CAUTION!! Use gloves or tongs to handle the dry ice. Do not touch it with bare fingers and do not breathe the fumes.*

(The resultant mixture of acetone and dry ice, with noticeable foaming due to the rapid release of carbon dioxide gas, gives a low temperature of around $-100°$ F.)

Place an object such as a piece of banana, a flower, or a piece of rubber tubing into the low-temperature mixture. Remove after several minutes and note the changes in the properties of the object. Pound it with a hammer. What happens?

III. Change is a continuous and inevitable process. Earth is constantly changing as forces act upon it.

A. Destructive forces are constantly changing Earth's surface by wearing it down.
   1. Weathering of rocks breaks them into smaller fragments.
      a. Changes in the atmosphere produce principal weathering agents.
         1.) Precipitation wears down rocks.

Measure the height to which soil is dislodged by rainfall by attaching a ruler to a wooden stake which has been firmly driven into the ground. Following a rainfall, check to see how high the dirt splashed. Wipe the ruler clean and record the splash height after other rainfalls. Note the variations and discuss reasons for them.

Observe that raindrops have weight. Children can feel and hear the raindrops striking umbrellas, rainhats, their faces. This shows weight in the raindrops. Watch and listen to the drops striking a window or a roof.

         2.) Temperature changes cause rocks to expand and contract; this stress causes rock fractures.

Heat a piece of sandstone for several minutes and drop it into a bowl of cold water. Observe results. Relate this to temperature changes which cause rock fractures. WEAR GOGGLES! ! !

Heat glass marbles in a frying pan for a few minutes. While still hot, pour them into a pan of cold water. After they have cooled, examine carefully to observe what has happened. WEAR GOGGLES! ! !

3.) Water expands when frozen and causes fractures in rock.

Fill a small jar with water and close tightly. Wrap the jar with several layers of cloth and tie with string. Put the jar into the refrigerator freezing compartment overnight CAREFULLY unwrap and examine contents of the package.

4.) Some substances dissolve in water to form weak acids which weather rocks.

Place an oyster shell (limestone) or animal bone into a jar and pour in vinegar. Close the lid. For several days observe what is happening to the shell or bone.

b. Plants and animals are also agents of weathing.

1.) Growth pressures from the germination of some seeds or the development of roots may break rocks.

Find places where plants are growing through the sidewalk.

Visit a cliff or stony hillside. Note how plants are growing there.

2.) Smaller plants such as mosses and lichens decay some rocks.

Find a rock where moss or lichen is growing. Remove a small portion of the plant. Compare rock texture there to rock without plant life.

3.) Animals contribute indirectly to weathering by burrowing activities which expose rock below the surface to other agents of weathering. Animals may also accidently break rock by kicking them loose.

2. Erosion carries the broken rock to a new location.

a. Wind blows rock fragments to new location.

Smooth and dry the sand in a sandbox. Place an electric fan to blow on the sand. Observe the movement of the sand. Place stones and small pieces of wood on the sand and see how these affect the pattern of sand distribution.

Identify sites of potential wind and water erosion in local community and suggest means of preventing this erosion.

b. Water in the form of rain, rivers, and waves moves weathered rock.

Put a few inches of soil into a quart jar. Add two cups of water. Shake. Examine the water periodically during the day and days that follow and note the rate at which the soil settles. How would the movements of water alter the rate of settling?

Refer to Interrelationships V-A-3.

Put some moist soil into an aluminum baking pan. Prop one end up a few inches and punch a hole in the other end to allow water to drain out. Place about a half cup of water into the soil each day. Notice over a period of several days how the soil is carried away and deposited by water.

Walk around the school grounds after a hard rain. Point out places where bare soil has eroded.

Visit a shoreline of the ocean or a lake and look for evidence of coastal erosion by storm waves. Find out what measures are being taken to protect property along the coast. Contact local engineering offices concerned with coastal protection. Find out the costs of protecting property from storm damage.

Take a field trip to observe erosion along a river bank.

View a film or filmstrip and look at pictures of the Grand Canyon to see effects of erosion. Relate to the formation of Natural Bridge.

Work in teams of four or five and collect gallon jars of water from a muddy stream. Filter water through a paper towel which has been weighed, dry, before being folded and inserted into the mouth of a funnel. When the water has been filtered, dry the paper with the sediment and reweigh it. Compare weight of dry paper to weight of sediment and paper in the various samples. How much sediment was contained in each gallon of water?

c. Glaciers and the forces associated with melting and movement erode Earth.

Obtain three ice cubes of equal size. Place each in a separate pan and label—A, B, C. Cover each with a piece of asbestos. Place a half-pound weight on cube "B". Place a full pound weight on cube "C". Each of the cubes begins to melt. "B" melts faster than "A", and "C" melts faster than "B". What is the reason? How would the weight of heavy snow and ice at the top of a mountain affect the glacier at the base of the mountain?

3. Weathering and erosion together are responsible for the formation of soil and broken rock on Earth's surface.

Wrap a rock in a cloth and break with a hammer. Place pieces in a jar of water. Shake 100 times. Examine rocks. Note that sharp edges are now rounder. Filter water through a paper towel and observe the smaller rock fragments from the original rock. WEAR GOGGLES when breaking rock!!

B. Constructive forces are constantly changing Earth's surface by building up or raising portions of the continents at irregular intervals.

1. Volcanoes build up Earth on the crust and below its surface.

Look for reports of volcanoes that were created where none existed before. Look for accounts of islands that were created by volcanoes or where islands were destroyed by volcanoes. Discuss the type of reporting and survey system used in different areas of Earth to keep track of active volcanoes, and the improvements that might be made in the surveillance of potential areas of volcanic eruption.

Make a small mountain of soil using a small container as the core. Place the mountain on a tray to catch the erupted material. Carefully place a small quantity of liquid soap in the container adding water until the container is about half full. Add several drops of brown and/or red food coloring. Lastly add a quantity of dry ice in small chunks to bring about a reaction. (*Note:* Dry Ice should be handled CAREFULLY!!! *Use gloves or several thicknesses of cloth when picking up the dry ice. Do not allow the dry ice to come in contact with the skin.*)

2. Earthquakes and other movements of the crust and bedrock change Earth.

Find information about the world-wide system for reporting earthquake disturbances; the types of warning and alerts that are broadcast; the tsunami warning system and the part of the world where it is most effective.

Locate the sites of most volcanic activity and earthquake activity on a world map. What reasons can be inferred for these locations?

C. The effects of destructive forces and constructive forces are balanced over a long period of time.

1. Deposition of eroded materials in deltas and on continental shelves results in accumulated weight.
2. Weight increase at the site of deposition is balanced by an uplift of material at another point.
3. Balance in constructive forces and destructive forces can occur because the mantle, or layer just under the crust, is pliable.
4. Forces that are modifying Earth's surface today have been operating for millions of years.

Fill a tray with sand. Place the tray slightly tilted above a pan. Pour water slowly over sand to make a stream of water. Observe the delta building up in pan. Has weight been transferred from one place to another?

Float four blocks in a tank of water. Place them in a single row. Place several weights on the two middle blocks. These blocks will float lower in the water. Shift the weights from these blocks to the others. Note that one block rises and the other sinks as the weights are shifted. (Erosion carries materials from the continents to the ocean floor. The ocean floor sinks under the weight of the sediment that accumulates. The continent, lightened by the loss of weight, rises.)

D. Some changes on Earth appear to occur in cycles.

1. Each season has its characteristic changes.

Play a word association game. Name one of the seasons and list in a few minutes as many words as possible which describe the season and its effects on plants and animals. Compile a list for the entire class. Repeat for other seasons. Examine lists for words which are characteristic of one season.

2. Tides occur in cyclic patterns.

Keep a record of the time of tides for several weeks.

View a film on tides and look for details about the cyclic nature of this event.

3. Some weather conditions seem to occur in cycles over long periods of time.

Study records from the class weather station and/or an official weather reporting station in the area. Identify, if possible, any cycles such as precipitation on certain dates or the coldest or hottest days of each year.

IV. Change is a continuous and inevitable process. Many kinds of change occur in the universe.

A. Exchange of energy is responsible for changes which occur within the universe.

1. Energy from the sun produces many changes on Earth.

List the many changes which occur on Earth as a result of the sun's energy. Prepare a bulletin board or a group of dioramas to illustrate the many changes.

2. Stars are changed as they produce radiant energy.

Study reference materials about the source of the energy of stars. As stars use up their available materials, what kinds of changes are observed?

3. Radiation may bring about helpful or harmful changes.

Classify the changes radiation may produce as helpful or harmful. (The opinions of children may differ on some points.) How many other phenomena and/or inventions have debatable "helpful" or "harmful" occurrences?

4. Energy from the sun as well as other stars is a product of nuclear changes.

View films about the sun or other stars to illustrate the source of their energy.

5. Stars may change temperature in cyclic patterns.

Heat a piece of wire until it glows. Note any change in color as heat is absorbed and as the wire cools. Relate this change in color to change in star color as the star cools. (Point out that our hottest stars are blue-white and white, and as they become cooler they turn yellow, orange, and then red over millions of years.)

B. Relative positions of celestial bodies in space are constantly changing in a predictable pattern.

Cut a one centimeter round hole in a piece of paper or cardboard. Place this in a south window of your classroom where the sun's rays will shine through the hole and strike a piece of white paper on the floor, the table, or window sill. Draw the outline of the spot where the beam of light strikes the white paper. Write the date and hour inside the outline. Repeat this on succeeding days at exactly the same hour. Do not move the materials between days.

Observe changes of positions of Earth with respect to the sun by marking a line on the floor or the wall where the sun shines in your room. Note the exact month, day, and hour. At the end of each week make another line at exactly the same hour. Repeat this throughout the year. (The variation in position of the lines from week to week and month to month is caused by the movement of Earth around the sun.)

Keep a diagrammatic diary on a chart or calendar of the moon's changes for one month. How many days were there between new moons and full moons? How many days from new moon to new moon?

1. In the solar system the nine planets revolve around the sun, as the satellites of planets revolve around those planets.

Darken the room and place a single light source in one corner representing the sun. Have one child stand in the center of the room with a poster in front of him showing the Western Hemisphere and one on his back showing the Eastern Hemisphere. (This could be a cloth cover-up apron with maps drawn in crayon and pressed with hot iron.) This child turns in place, each turn representing one rotation. Keep track of time by flipping a calendar. Have another child, representing the moon, move around the Earth child constantly facing him. He must travel slowly enough to take a month-of-days to complete the circle. Have different children play the role of Earth and moon so that each may experience the perspective of both positions and the time required by each movement.

Use water proof paint to draw the solar system to scale on the blacktop area of the playground. Refer to Space IV-B-1.

2. Comets travel around the sun in elliptical orbits.

Read about Haley's Comet.

3. Some stars revolve around another star.

Visit a planetarium and ask the director to show this with the equipment.

V. Change is a continuous and inevitable process. Man must learn to live in harmony with change and his activities should enhance, rather than imperil, natural conditions that result from change.

A. Matter and energy exchanges occur in a continuous cycle involving living and non-living matter.
   1. Energy and inorganic matter become part of organic matter through various processes of the cycle.
   2. Through action of organic systems involved in the cycle, matter is broken into energy and simpler substances.

Refer to Adaptation I-A-2 and 5, I-B-2 and 5, Change I-A, Equilibrium I-B, Interrelationships I-A, and Variety I-B-1, and develop the overlapping ideas in these sections.

B. Man's use of science and technology has caused changes in the environment which are beneficial as well as harmful.
   1. Some of man's efforts at environmental control may directly affect a cycle; for example, cloud seeding affecting the water cycle.

Read reference materials about man's attempt to produce rainfall and to control hurricanes by cloud seeding.

Study examples of man's activities which affect life cycles of various organisms such as fish hatcheries, reforestation, seeding of oyster beds, or the transporting of animals from one location to another.

Refer to Equilibrium V-C-4.

   2. Other applications of technology to environmental control may indirectly affect a cycle, and while beneficial to one segment, they may be harmful to another.

Investigate the effects of practices such as spraying oil on water for mosquitoes, use of various insecticides for insect control, cutting large tracts of timber, controlled burning of fields, trash, or dumps, and construction of dams.

Refer to Organization V-C-2.

C. In view of constant change, maintaining a life-supporting environment requires governmental cooperation at local, state, national, and international levels.
   1. Individual citizens can bring about changes through local groups which present problems and recommendations to legislative representatives.

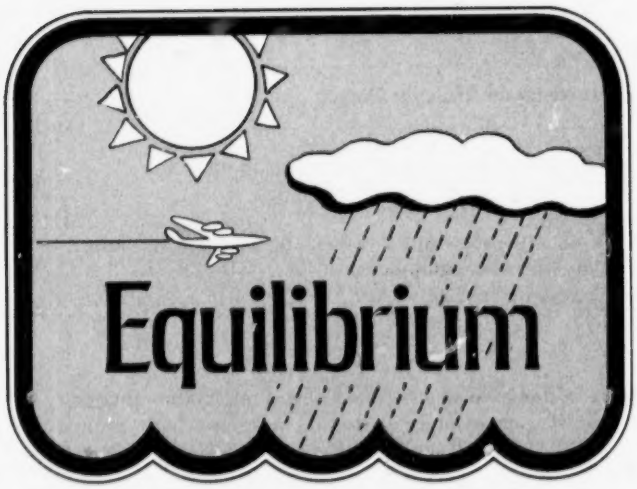
Hold discussions in each class on the topic, "How We Can Improve Our School Environment." Elect representatives to a school environmental council or work through the existing SCA structure. Have the council implement a plan for environmental improvement involving the entire school. Strive for a sustained effort rather than a one-or-two-week project.

   2. Technologically advanced countries can assist other countries in avoiding some problems with resource use and industrialization by pooling knowledge and experience.

Locate some of the countries that have teams of technicians from the U.S. which assist in different programs of technical aid. Also, determine some of the countries in which Russia has teams of technicians. Identify the type of programs for which aid is being given.

D. Many adjustments to changes in the environment are necessary from one generation to another.
   1. Resource depletion leads to a need for new sources of raw materials, other types of resources, or recycling.

Develop a display of "endangered" resources, and possible new sites for locating new resources. What types of energy might be utilized in the future to replace the dwindling amounts of fossil fuels now used? What types of materials can be recycled to extend resource availability? Relate to renewable and non-renewable resources in Organization V-B.



EQUILIBRIUM is a condition in which opposing forces and processes counterbalance each other.

The establishment of equilibrium involves the continuous interaction of these factors in the universe in an attempt to restore balance and stability as imbalance occurs. These interactions may occur in a moment of time, or they may be observed only after centuries of time have elapsed. The erosion of land areas at one point and the uplift of new mountains at another point is an example of opposing forces at work which tend to establish equilibrium.

The restoration of balance or equilibrium involves change. Cyclic as well as non-cyclic changes are necessary for establishment of equilibrium. Cyclic patterns are exhibited in the movement of water through the cycle of precipitation, evaporation, and condensation, and the forming of soil from rock and rock from soil.

Man sees the necessity of balance in a manned space craft leaving Earth, and is becoming more aware of the same necessity on Earth. Man is challenged to work in harmony with the laws of nature while pursuing the necessary and satisfying activities of civilized life.

EQUILIBRIUM

I. Interaction of natural forces tends to result in equilibrium. Living things and non-living things tend to exist in a balanced relationship.

A. Within a system relationships exist between plants, animals, and non-living matter as each organism functions to meet its basic needs.

1. A system is balanced when basic needs are met.

Establish and maintain a terrarium or an aquarium. Discuss the relationships between the elements composing the balanced system.

2. An exchange of matter occurs between living things and their environment.

Prepare a bulletin board illustrating the needs of living things, matter in the environment which is used to meet needs, and matter from living things which is returned to the environment.

3. Succession from the primary state to a stable community of living things is an orderly process.

4. The kinds of plants and animals in a community may change as the physical factors change.

Refer to Adaptation V-A.

Take a field trip or several field trips to sites in the various stages in succession. Include sites such as a pond which is filling with sediment, a marsh, a field, transitional zones, and a wooded area. Make sketches or take pictures of the various sites and place them on the bulletin board to illustrate succession. (Emphasize that the process may take a long time to occur in a given area provided it is not influenced by man. The bulletin board display could include animals which move in as the plant succession occurs.)

5. Size and structure of an organism is limited in part by environment.

Obtain two similar green plants. Place one in sunlight and the other in a shaded place. Observe any difference in size and development.

Refer to Space I-B-3.

B. Energy is passed from one organism to another in food chains which are linked in food webs within a system.

1. Life on Earth is dependent on radiant energy from the sun.

Grow plants in sunlight along with all other necessities for life and grow other plants with identical plant foods, but with the absence of sunlight. Observe and record differences over a period of time.

Use reference materials to determine factors which make Earth more suitable for life than other planets. Compare factors such as water, temperature, and length of seasons.

2. Living things can transform energy into a variety of forms.

Investigate the topic of bioluminescence or living lights as seen in fireflies, glowworms, and some molds, mushrooms, and bacteria. Books on this topic are available.

Observe other results of energy transformations such as growth and movement in plants and animals. Refer to Adaptation I-A and B.

3. Living things must have a continuous supply of matter and energy to function.

Plant several seeds in two containers. Use plastic bags to deprive seeds in one container of water, air, and sunlight for a period of time. Compare with other plants in control container.

Collect samples of soil from a variety of locations and notice the types of plants which grow in each area. Examine the soil samples and discuss differences. Does the soil in a carefully kept flower garden differ from the soil from a vacant lot? Would the flowers grow as well on the vacant lot? Why?

4. Organisms in a food pyramid exist in a numerical relationship to each other.

Arrange pictures of prey-predator species in a display. (Note that in such a relationship one finds more prey than predator in a balanced environment. Frequently the transfer of energy through a food chain can be described on a one to ten basis. In a system existing on one kind of food there is a far greater mass of living material at the bottom of the pyramid.)

Man	1 lb.
Big Fish	10 lb.
Small Fish	100 lb.
Crustacean	1000 lb.
Algae	10,000 lb.

SAMPLE FOOD PYRAMID

5. Green plants are food producers.

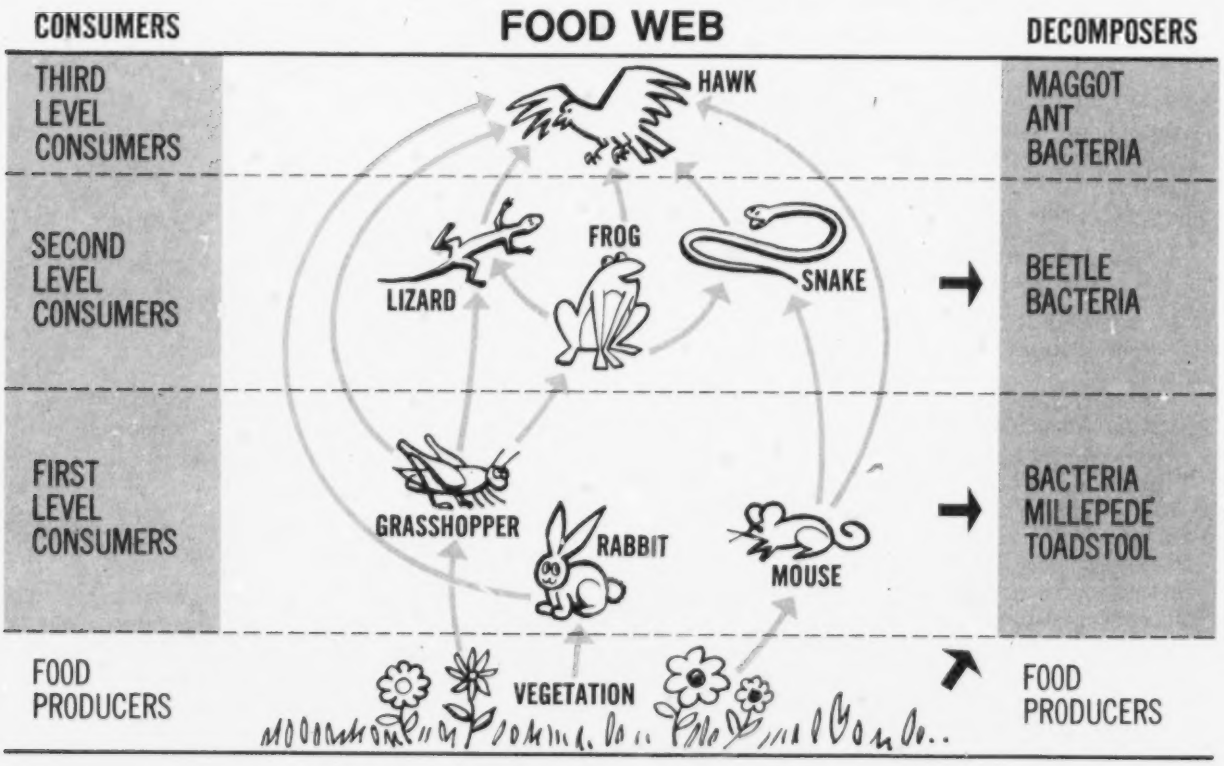
Trace each food on the school menu back to green plants.

Determine by observation and research how pets are dependent upon green plants.

Make charts showing herbivorous animals.

Place the green water plant, elodea, in a closed plastic bag filled with water. Weigh carefully. After a month weigh again. (Notice that the plant stem has grown but the weight of the bag has not changed.) Explain the results.

6. Consumers are classified according to their position in the food chain.



Prepare a bulletin board display of a food web and label each organism. Point out food producers, first, second, and third level consumers, and decomposers. Note energy flow in the web.

7. Decomposers return basic elements to the environment.

Research decomposers and report on their life processes and methods of decomposition. How would the world be different without decomposers? Are the functions of decomposers vital to the continuity of life?

Refer to Change I-C-3.

C. Animals tend to assume a stable position in interactions with the environment.

1. Body symmetry helps an animal to maintain balance.

Look at the bodies of different animals. Pay particular attention to the number, kind, and shape of appendages. Look at pictures of various animals and note body summetry. Refer to Adaptation I-A-1.

2. Controlled movement of animals is sometimes influenced by the need to maintain balance.

Watch animals walk, run, leap, lie down, and get up and describe the methods they use to maintain balance. Mold from clay, paper mache, or other media animals in various positions. (In the primary grades have children imitate the way various animals move.) Refer to Adaptation I-A-1.

3. Internal structures help animals to maintain balance.

Visit the museum to see skeletons of various animals and observe the symmetry of the bony structure.

Study the functioning of the inner ear as it relates to balance.

4. Activities of man are often affected by his control, or lack of control, of balance.

Observe activities such as skating, riding a bicycle, or walking a balance beam in which control of balance must be acquired.

D. Regulatory mechanisms within organisms help restore equilibrium as needed.

1. A departure from the normal body conditions may bring about change in temperature as regulatory functions attempt to restore equilibrium.

Run around the playground. Note changes in body functions such as breathing, perspiration, and pulse rate. How are these changes related to equilibrium?

Observe change in size of the eye pupil in bright and dim light.

2. Living organisms may develop protection against disease and foreign materials.

Study the function of the tear glands in removing foreign materials from the eye. Study first aid procedures for removing various materials from the eye.

Investigate the function of white corpuscles, clotting, and scar tissue.

3. Various methods have been developed to aid the body in restoring and maintaining chemical equilibrium.

Have each student list the diseases for which he has received some type of immunization. Discuss the methods by which immunization treatments are administered. Determine the diseases for which all children have been immunized. Explore references to learn more about diseases for which children have been immunized. Discuss why this treatment is so important to them.

Discuss the aids that have been developed to help people who have diabetis, epilepsy, and other problems of chemical equilibrium.

4. Living things are able to make some adjustments to variations in temperature.

Study the adjustive capability of non-migratory species of the temperate zone.

Visit a zoo. Ask the zookeeper or zoologist about provisions made for animals from different climates. Which animals adjust more easily, those from a cold climate or those from a warm climate?

II. Interaction of natural forces tends to result in equilibrium. Matter and energy may be transformed, although the sum of matter and energy remains constant.

A. Energy must be applied to produce motion.

1. For every action there is an equal and opposite reaction.

Discuss and show diagrams of a person swimming or rowing a boat to note how pushing the water back enables an object to go forward.

Blow up balloon and release to show propulsion.

2. Forces are balanced when they are applied equally but oppositely.

Place weights on each side of a balance scale until balance is achieved.

Roll a ping pong ball down the center of a table. Have a team of children on each side. Object of the game is to blow the ball off the table on opposing team's side of the table. When does the ball seem to stay in the middle of the table? Play tug-of-war. Is the principle the same?

3. Balanced forces result in a state of inertia in which matter is at rest or in motion.

Place a 3" x 5" card over the mouth of a glass and place a coin on top of the card. Using the thumb and index finger flick the card suddenly from under coin. Observe results. (Inertia of the coin tends to make it remain at rest; however, the force of gravity pulls the coin into the glass.)

Start a top spinning. After a few moments observe the slowing of the spinning. How do friction and gravity function as unbalanced forces to overcome the spinning of the top? What energy started the top spinning?

4. Force is needed to start, stop, or change the direction of an object in motion.

Roll a ball across the floor to show force to start the motion. Roll a second ball across the floor and allow the two to collide. Notice the path the two balls follow. What makes the balls stop rolling?

B. Energy may be transferred from one place or object to another.

1. An object placed in a new environment will gain or lose heat energy until it reaches the point that its temperature will be in a state of equilibrium with its surroundings.

Obtain a cup of ice water and a cup of hot water from the cafeteria. Place a thermometer in each cup. Every ten minutes record the temperature of each cup until both cups reach room temperature. Show the results on a graph.

2. The gain and loss of energy by Earth is in a fairly stable state.

Observe radiant energy striking various surfaces. Place thermometers in containers covered with materials of various textures and colors. Place containers in direct sunlight. Record thermometer readings every five minutes for a total of 30 to 60 minutes. Graph results. Do some surfaces absorb heat better than others? Do some surfaces reflect heat better? Relate reflection and absorption to texture and color. How does the presence or absence of cloud cover affect Earth's temperature?

III. Interaction of natural forces tends to result in equilibrium. Earth's surface is constantly shifting toward stability.

A. The hydrologic cycle causes changes on Earth.

1. Water evaporates from the surface of Earth.

Observe the playground at different times after rain. Take photographs periodically and place in order when developed.

Measure the size of a puddle periodically and record results as evaporation occurs.

Show evaporation by placing container of water in classroom window.

2. Plants give off water which has been absorbed from the soil in a process called transpiration.

Observe water accumulation on the inside of a terrarium.

Obtain a healthy plant and cover the leaves and main stem with a plastic bag. Continue to water as usual. Observe results.

3. Rate of evaporation and transpiration is affected by the movement of air.

Acquire two similar containers of water. Use an electric fan to blow air across one container. Let the other container sit undisturbed in the room. Observe difference in rate of evaporation.

4. Movement of soil is affected by the action of water and air currents.

Place different soils in sand table. Use fan to blow soil. Observe where soil comes to rest. Pour water over soils and observe what happens.

Bring in newspaper clippings, showing results of wind, storms, and floods.

5. The sun is the source of energy for changes on Earth's surface.

Place a pan of water in sunshine and measure the gain of energy (change of temperature) with a thermometer at periodic intervals. Record results.

Prepare poster illustrations of the hydrologic cycle stressing the heat of the sun as the energy that powers it.

6. Loss of heat energy by clouds results in precipitation.

Review water cycle and perform activity in Interrelationships III-A-5.

B. High places on Earth are eroded as forces within Earth elevate other areas.

1. Several theories have been developed concerning changes in Earth's crust.

a. The lithosphere may be affected by gravitational forces which cause ocean tides.

Show a film on ocean tides. Relate this to gravitational effects on molten magma.

b. Hot molten magma shifts within Earth.

Refer to Change III-B and C.

2. Earthquakes are caused by the breaking and slipping of rocks in Earth's crust as a result of pressure differences.

a. Most earthquakes and volcanoes tend to occur in the same general areas.

Show a film on Earthquakes. Read reference materials and develop models.

Consult resource material to find maps showing where earthquakes are most likely to occur. Compare and contrast topography, climate, and other factors in these areas.

b. Magma sometimes breaks through Earth's surface as a volcano.

Saturate a small area on a paper bag with water. Fill the bag with gravel or other substance. Shake the bag and observe where weakness is evident. (Eventually the weak spot will give way as Earth's surface does at times.)

C. Differences in air pressure create movements of air which tend to equalize air pressure on Earth's surface.

1. A layer of air surrounds Earth and is called the atmosphere.

Invite a resource person from local weather station to tell about air motion and air pressure.

2. The weight of the atmosphere presses on Earth.

Bring instructions from cake mix boxes that state different temperatures for baking at different altitudes.

Measure atmospheric pressure with a barometer such as the one suggested in Variety III-A-5.

3. Air moves from a region of high pressure to a region of low pressure.

Use weather maps to trace the movement of pressure areas across the U.S.

Explore the interrelationships between high and low pressures, temperature variations in relation to pressures, humidity, and convection currents.

4. The rate of air movement affects its pressure.

a. The faster that air moves the less its pressure.

b. The slower that air moves the greater its pressure.

Place one end of a sheet of paper between the pages of a book allowing the paper to hang down across the cover. Hold the book level with your lips and blow over the top of the paper. What occurs? Explain why.

Cut a strip 2" x 8" from a 5" x 8" index card. Bend the strip and staple the two ends. Curve the top edge and keep the bottom edge straight similar to a cross section of an airplane wing. Place a round pencil or knitting needle through the loop and blow across the curved surface of the cardboard wing. What occurs? Why?

5. Differences in the temperature of land and water cause movements of air characteristic of coastline areas.

Place some soil in a glass container. Place water in a second container to the same height as the soil. Place a thermometer in each container and allow temperatures in containers to become equal. Place the two containers with thermometers in sunlight and record temperature readings each 10 or 15 mintues for an hour. Record results on a graph. Note difference in rate of temperature change. Relate to formation of sea and land breezes.

D. Movement of water in the ocean helps equalize distribution of energy and matter.

1. Temperatures and salinity of the ocean vary widely over a period of time.
2. Heating and cooling change the density of water.

View the film, "The Restless Sea," produced by Bell Telephone.

IV. Interaction of natural forces tends to result in equilibrium. Forces tend to exist in a balanced relationship in the universe.

A. Flight involves an interaction of forces and a controlled adjustment to equalize them.

1. Air exerts pressure.

Fill a drinking glass full of water. Place a piece of cardboard over the top. Hold the cardboard in place and turn the glass upside down. Remove the hand holding the cardboard. What holds the water in the glass? (Air pressure against the cardboard is greater than the water pressure against the cardboard. Repeated efforts may be necessary to obtain expected results in this activity.)

Prepare a graph of barometric pressure readings taken at the same time over a period of several days. Note the changes in air pressure. Refer to Variety III-A-5.

2. When the speed of a stream of air increases, the outward pressure of air decreases.

Refer to Equilibrium III-C-4 and perform activities.

3. The flight of a heavier-than-air craft is dependent on the interaction of four forces: drag, thrust, lift, and gravity (weight).
4. The design of an aircraft provides for the effective interaction of forces and their control.
5. During level flight of an aircraft, lift is equal to gravity and thrust to drag and the aircraft continues to move due to inertia.

Relate drag to friction as described in Interrelationships II-B.

Demonstrate thrust by releasing air from balloon and observe the results.

Perform activities in Equilibrium III-C-4 in which the air flowing over the top of the wing moves faster with less pressure than that below the wing. (This imbalance in pressure provides lift.)

Visit an airport to see an airplane and discuss the function of various parts of the airplane.

Explore the function of streamlining of a body in relation to drag produced during motion of the body through air or water.

Refer to Equilibrium II-A-3.

6. Efficient equilibrium systems must be provided in order that man and animals may survive in space travel.

Consult various reference materials for further information concerning space travel and the life-support systems provided.

Refer to Space IV-C-3.

B. Motion, gravitation, and gyroscopic stability are involved in maintaining equilibrium within the universe.

1. The orbits of celestial bodies are explained in terms of equilibrium between inertia and gravity.

a. All bodies in the universe react to gravitational attraction.

Drop a ball to the ground. What force causes the ball to return to Earth's surface? Jump a short distance; try very hard to jump farther; now run and jump. What differences are observed between energy in-put and length of the jump?

Weigh various objects using a spring balance or bathroom scale. Discuss weight as the measure of gravitational force.

Relate movement of astronauts on the moon to the reduced gravity of the satellite.

b. The nature of gravitational fields determines paths of objects moving within or through them.

Read articles in newspapers and magazines about current space exploration activities. How is the force of gravity of an object used to establish an orbit? How must the effects of gravity be overcome to launch or land a space vehicle?

c. All orbiting bodies seem to follow the same laws of motion, implying that the force of gravity operates throughout the universe in the same way.

d. The establishment of equilibrium of forces prevents planets from being drawn into the sun or being moved outward from their orbits.

Attach a string three to five feet long to a ball. Whirl the ball around. Release the string. Why does the ball travel in a straight line? What causes the ball to fall to the ground? (The balance of interacting forces of gravity and inertia result in an orbit of one object around another.)

2. Earth, moon, and sun are continuously changing position with respect to each other in a pattern which can be predicted.

Refer to Change IV-B, Motion IV-B, and Organization IV-A and perform suggested activities.

3. The period of revolution of the planets about the sun varies directly with their distance from the sun.

Draw several concentric circles on the playground. Measure the radius and circumference of each. Use a stop watch to record time needed to walk around each of the circles. Record results on a chart. Relate to the period of revolution of the various planets.

C. An object tends to maintain its position in liquids or gasses when opposing forces are balanced.

1. Objects weigh less in water since they are buoyed up by a force equal to the weight of the water they displace.

Dramatize the story of Archimedes.

Use a spring balance to weigh objects such as washers, nails, floating toys, and rocks. Record the weight of each object. Suspend the objects in a container of water, and record the weight. Compare results on a chart.

2. A denser liquid has more buoyant force.

Place a lump of clay in the bottom of a dry test tube. Allow the test tube to float in a container of water. Mark the water line with a grease pencil. Float the test tube in tomato juice, molasses, mineral oil, milk, alcohol, or other liquids and mark the fluid level on the tube. Compare results. How is this related to a hydrometer?

3. Objects of less density tend to move upward in materials of greater density.

Mix cooking oil and water. Set aside and observe reaction. How is this separation prevented in some salad dressings, milk, and similar products?

D. Man has developed ways to control and maintain pressure.

1. Man has developed means to protect his body in travel and exploration.

Discuss and list protective factors which must be taken into account when designing the space suit, space capsule, and life-support system. Relate to life needs.

Refer to Space IV-C-3.

2. Man has learned to control pressure of liquids and gases for useful purposes.

Investigate devices which operate by reason of decreased air pressure (medicine dropper, vacuum cleaner, suction cup), increased air pressure (air brakes, deep sea diving suit, auto tires, basketball), and liquid pressure (hydraulic lift, brakes, press). Study examples which are not listed here and classify according to type.

V. Interaction of natural forces tends to result in equilibrium. Man must learn to live in harmony with equilibrium and his activities should enhance, rather than imperil, balanced natural conditions in the universe.

A. Man's alteration of the environment may upset the balance in biological communities.

1. All organisms have a role in the natural world.

Refer to Change I-A and C, Equilibrium I-A and B, Interrelationships I-A, and Organization I-D.

Select an animal or plant and study the various ways in which the organism interacts with the biotic and abiotic aspects of its environment. Use actual observations out-of-doors, when possible.

2. Indiscriminate use of pesticides and herbicides may affect equilibrium in two ways:
   a. immediate imbalance;
   b. future imbalance as the result of cumulative, potentially detrimental effects.

Invite a farmer, agriculture teacher, or other person familiar with pesticides and herbicides to visit the class or to be interviewed by a class committee. Explore the effects of various chemicals upon the environment. Why are many of these products labeled as poisons? What precautions should be taken in their storage and use?

Read the book, *Silent Spring*, by Rachael Carson, Houghton-Mifflin, Boston, 1962.

3. Man's artificial control of reproductive processes and dissemination of living things may upset the natural equilibrium of biological communities.

Read to find examples of dissemination of organaisms into a new environment, such as the introduction of rabbits into Australia, and English sparrows and starlings in this country. Also try to locate information about the control of reproduction in pigeons now being tested by some cities.

B. Man's activities often change the environment too rapidly for natural regulatory mechanisms to maintain equilibrium.

1. Concentrations of population in certain areas alter the physical and biological environment.

Refer to Space I, and V-B and C.

Visit an area of rapid growth. What demands are made upon the environment in relation to the life needs of residents? Check with local officials about increasing water and power consumption, solid waste disposal problems, erosion of land, and traffic management. Develop alternative solutions to the problems, and hypothesize the results of each solution.

2. Man may alter evolutionary processes when he moves organisms from one community and introduces them into another community.

Contact U. S. Customs about regulations governing import of plants and animals. What reasons can be determined for these regulations?

Read about the activities of various wildlife groups which transfer animals from one location to another when the lives of the animals are threatened by overpopulation, urbanization, and other factors. (In Virginia beavers, elk, and deer have been relocated.)

3. Man may create conditions which lead to the extinction of some organisms.

Refer to Organization V-B-5 and Adaptation V-B-1. Relate the needs of living things met within the environment to the alteration of an aspect of the environment by man.

Investigate practices such as over-hunting or overfishing in relation to endangered species as determined by groups such as the National Wildlife Federation or the Fish and Wildlife Service of the U. S. Department of Interior.

4. Accumulation of waste products from man's activites may exceed the natural recycling processes.
5. Some of man's activities produce pollutants which are released into the atmosphere, hydrosphere, and lithosphere.

Refer to Change I-C-3, and V-A, Equilibrium I-B, Interrelationships I-F, Motion V-B, and Space V-B and correlate suggested activities.

Look for examples of waste product accumulation in your school and community. Initiate corrective measures when possible.

Prepare a display or list of non-biodegradable waste products.

C. Plans for efficient use of natural resources should provide for restoration of renewable resources at a rate comparable to their consumption.

1. Excessive lowering of the water table, inefficient management of surface water, waste, or failure to adequately provide for reuse may reduce the supply of potable water to dangerous levels.

Refer to Organization V-B-4.

Pour equal amounts of water into a tall, cylindrical container, and into a shallow, flat container. Allow to remain undisturbed in the room for several days. Which container was empty first? Why? What process is illustrated? How does the ratio of surface area to depth of reservoirs relate to this activity? What engineering problems are associated with building deep reservoirs in topographically flat areas? What ecological problems arise with reservoirs in relation to flooding of an area?

2. Man attempts to restore equilibrium in plant and animal communities by such practices as reforestation, controlled hunting and trapping, and agricultural conservation.

Study hunting, fishing, and trapping regulations for the last several years, noting especially changes in bag limits, length of season, and number of open days.

Visit a reforestation site, if possible. Talk with the supervisor about the need for reforestation, and anticipated results.

3. Man may maintain levels of soil fertility by chemical fertilization and crop management.

Ask a local soil scientist or farmer to discuss fertilization and crop management procedures used in the area. Visit suggested sites.

Investigate the problem of run-off of chemical fertilizers into streams and ponds. What effects do the fertilizers have upon plants living in the water? What types of changes might take place as a result of this?

4. Man seeks to reestablish animals in their natural environment by such activities as restoring animal herds, restocking streams, and replenishing oyster beds.

Visit a fish hatchery or oyster seed bed. Talk with supervisors about the function of these projects in relation to environmental equilibrium: How is the number of organisms an area can support determined? When is the new stock transferred to the new environment? How is the timing of the move related to the reproductive cycle of the organism?

D. Wise use of non-renewable resources should involve a minimum of misuse and damage, and a rate of consumption which extends their availability over a maximum period of time.

1. Recycling of mineral products and organic material can reduce the drain on original sources.
2. Increased efficiency of individuals, government, and industry can reduce misuse, damage, and waste of valuable resources.

Refer to Change V-D-1, Organization V-B, and Space V-A.

Look for ways of reducing misuse and waste of materials in your classroom and in the school. Initiate corrective measures.

Investigate the by-products of the recycling process of a waste material. Are the by-products detrimental to the environment? What ecological and economic limitations are associated with recycling?

E. Man's activities may adversely affect equilibrium of temperature on Earth's surface.

1. Waste water from industrial plants may cause thermal pollution by upsetting the natural cyclic temperature changes of a stream.

Locate industries in your community which use water in their processes. Is the water temperature returned to normal before discharge? If not, what is the difference in temperature of the water taken in and the water discharged? How might this temperature difference affect plants and animals living in the stream?

2. Heat produced by man's activities may affect circulation and temperature in the atmosphere.

Investigate the functioning of air-conditioners, refrigerators, and other mechanical cooling devices. What happens to the heat these devices remove from the air? How do various heating systems function? How does insulation of a building prevent heat loss into the atmosphere? Why are air temperatures generally higher in downtown areas than in open fields?

3. Two major theories about the effects of air pollution predict conflicting results:
   a. The greenhouse effect results in an increasing atmospheric temperature which will melt the polar ice caps and flood Earth's surface.
      1.) Carbon dioxide accumulates in the atmosphere and results in the greenhouse effect.
      2.) Carbon dioxide acts as a one-way filter allowing sunlight to pass through but preventing its reflection from Earth's

surface, thus accumulating heat in the atmosphere.

3.) Increase of atmospheric temperature by six degrees could melt enough polar ice to increase sea level by several hundred feet.

Visit a greenhouse and ask the supervisor to explain its operation.
Relate to heat accumulation in a closed automobile in the summer.

b. The screening action of pollutants results in a decreasing atmospheric temperature which will freeze additional water into ice.

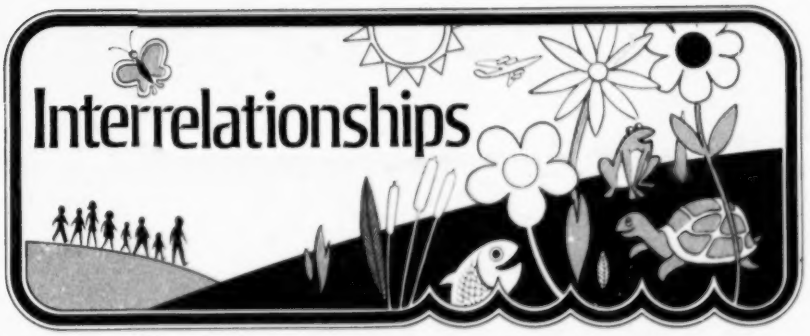
1.) Particulate matter accumulates in the atmosphere and results in screening action.

2.) Particulate matter allows less sunlight and heat to reach Earth's surface, thus lowering atmospheric temperature.

3.) A drop in average temperature of only four or five degrees may be enough to begin another ice age such as Earth has had.

c. Both theories have scientific support, but long range results are unknown. Perhaps the effects of the two are in balance and no change will occur.

Relate to tinted plastic now being used to cover a patio. (This allows light through but screens heat.)
Locate current information on these theories. Is one theory gaining more acceptance than the other?



FORCES, forms of energy, and living and non-living matter interact to form the environment. Virtually nothing exists independent of other living or non-living matter.

Living things are dependent on other living things and upon their physical environment. The interdependence of plants and animals within the environment is essential to maintenance of life on Earth. All life forms are dependent upon water which is the basic component of the protoplasm of all cells; just as most life forms are dependent either directly or indirectly on the soil for their food supply.

The interrelationship of forces in the solar system maintains a pattern of revolution around the sun. Climate and patterns of tides on Earth are likewise affected by the interaction of various forces. All matter on or near Earth is affected by Earth's gravity.

INTERRELATIONSHIPS

I. All phenomena are interrelated within the environment. Living things are interrelated with other living things and with their physical environment.

A. Living things require a continuous supply of energy from the environment.

1. The sun is the ultimate source of energy upon which living things are dependent.

Place a small but healthy plant (geranium, coleus, wandering Jew) in a box from which all light can be excluded. Keep it in the box until the chlorophyll has disappeared and the plant has a bleached appearance. Then place it in sunlight again. Notice the change in color which occurs in two or three days. What inferences can be made about the change in color?

Obtain similar types of plants growing under similar conditions. Deprive one of sunlight by covering leaves with paper or cloth. After several days or weeks remove the covering and compare the leaves as to color, size, and general development. Discuss the value of sunlight for plant growth and development.

2. Green plants are the direct or indirect source of nutrients for animals and non-green plants.

Use charts, pictures, films, and filmstrips to trace the origin of food for man. Refer to Equilibrium I-B-5 and 6.

Plan a menu which the class would like to have for lunch. Trace the origin of each type of food back to green plants.

Take a field trip to find evidence of non-green plants living as parasites (corn smut, rusts, lilac mildew) on other living things, or as saprophytes (mushrooms, shelf fungus) on decaying matter. Refer to Equilibrium I-B-7.

3. In the process of photosynthesis, green plants use water and carbon dioxide from the environment and energy from the sun.

Perform activities relative to photosynthesis as described in Adaptation I-B-2-a.

4. In the process of photosynthesis, green plants give off oxygen which is essential to living things.

Perform activity one in Adaptation I-B-2-a.

5. Animals obtain food from plants or other animals.

Use reference material to read about different sizes and kinds of animals which are carnivorous, herbivorous, and omnivorous. Classify pictures of animals according to type for a bulletin board display.

Observe as many animals as possible over a period of a few days. List the things which are necessary for the animals to live. Compare and discuss the lists.

Prepare a bird bath and bird-feeding station on the schoolgrounds. Offer different types of food, including various seeds, for the birds to eat. Record what food different birds seem to like best.

Discuss the kinds of food which pets eat. List each type of animal and the types and amounts of food consumed. Discuss and compare the variety of foods among the different animals.

B. Living things are interrelated with other physical aspects of the enironment.

1. Living things are dependent upon water.

Prepare three identical pots of soil. Plant five to ten lima bean seeds in each pot. Number the pots 1, 2, and 3. Set them side by side so that all will have a similar environment. Keep pot number 1 soaked with water, and set in a dish of water. Keep pot number 2 moderately moist at all times. Do not water pot 3 except immediately after planting the seeds. Compare results.

Obtain two plants (geraniums) of the same kind and approximately the same size. Water one of them regularly, but do not give the other one any water. Note carefully the differences as time passes. Make measurements, leaf counts, and accumulate other descriptive data.

Read reference materials to find the length of time various living things can survive without water. Note especially the plants and animals of dry regions.

2. Most living things can exist within a range of temperatures, of light intensity, and of pressures of air or water.

Use reference materials to study about people who live in various climatic areas of the world. What ranges of temperatures must they endure? Are the changes of temperature daily or seasonal? What means have the people employed to make their lives more comfortable?

Obtain acetate sheets of various colors (blue, red, green, yellow, and transparent). Obtain twice the number of plants of similar size as you have acetate sheets. Prepare a cardboard box by removing one side and taping the acetate sheet over the opening. Put a plant inside each box allowing light to reach the plant by shining through the colored sheet. Use the other plants for controls. Measure plants weekly and graph results. Water all plants as needed. Compare growth results. Infer the effects of the filtered light on plants.

Read about the swim bladder (air or gas bladder) of some fish. How does the fish use this to adjust to the depth of water?

Show the effect of low temperature on a cold blooded animal by placing a frog in a container of water to which some ice is gradually added, lowering the temperature of the water slowly. Observe the inactivity of the frog as the body temperature drops near that of the water. Allow the frog to warm up gradually and observe change in activity.

Put one young potted plant by a window in the sunlight and a second potted plant of the same size under a box. Water both plants as needed and measure their growth each day. Graph the measurements. (It may be surprising to some children that, for several days, the plant in the dark will grow more rapidly than the plant in the sunlight.) Continue the experiment long enough to observe the eventual effect of the absence of sunlight on the covered plant.

Study about the inner ear of man. How does man react to changing altitude by decreasing internal pressure?

3. Sprouting of seeds results in roots growing downward and stems upward.

Fill small glass containers with cotton. Place seeds between cotton and outside glass so the seeds can be observed easily. Wet cotton. Observe seeds several days for development of shoots and roots. After this is easily seen, invert the glass. Observe again after several days.

4. Green plants grow toward light.

Place a potted plant in a box which has an opening near the level of the leaves. Place the box so sunlight will come through hole. After several days examine the plant, and note the direction the plant is growing. Turn plant so leaves are away from opening. After several days reexamine the plant and note the direction leaves have turned. The plant should be watered as needed.

Plant a sprouting potato in a pot of soil at one end of a long narrow cardboard box. Cut a hole in the opposite end of the box. Arrange baffles in the box so that the vine will turn two or three corners as it grows. Observe the direction of growth.

C. Living things are affected by natural cycles.

1. Water cycle

Observe the covered, classroom terrarium for evidence of the water cycle. What is the source of the water drops on the inside of the glass?

2. Oxygen-carbon dioxide cycle

Prepare a bulletin board, diorama, chart, or other visual presentation which illustrates the movement of oxygen from green plants into the atmosphere where it is then used by both plants and animals in respiration. (The respiration process produces carbon dioxide which is utilized by green plants in photosynthesis.)

3. Rock-soil cycle

Prepare a bulletin board, diorama, chart, or other visual presentation which illustrates the factors which break rock into small fragments (Refer to Change-III-A-1), the decay of organic material into humus through the action of non-green plants, the erosion of areas lacking in plant growth (Refer to Change-III-A-2), the transportation of silt by streams and rivers (Refer to Change-III-A-2), the deposition of silt (Refer to Change-III-C), and the pressures which may result in the deposited materials being changed to sedimentary or metamorphic rock (Refer to Organization IV-B-4.)

D. Multicellular organisms are composed of interrelated cells, tissues, organs, and/or systems.

Use appropriate charts, films, filmstrips, and pictures to show the various systems of higher animals. Through discussions and investigations children can discover that each multicellular animal has special cells which perform special functions.

Scrape the inside of the mouth gently with sterile cotton swab. Rub the swabbed material on a clean glass slide. Stain with blue ink. Place the slide under a microscope and observe cells.

E. A community includes a variety of plants and animals which are interdependent and suited to the environment.

Observe the activities of ants on a field trip to an ant colony. Gently open the colony with a stick, noting the response of the ants, the way in which they carry their pupae, the means by which they protect themselves, and the possible sources of food in the area. Return the colony to original condition as nearly as possible.

Observe the location, quantity, and kind of plant growth in a pond. Note the amount of light. (Without light and some degree of heat there would be no green plant growth which furnishes food and oxygen to living things in this particular community.)

Refer to Equilibrium V-A-1.
Show films or filmstrips about different plant and animal communities.

Select a plot of land for study throughout the year. Make observations, measurements, plant and animal counts, and other descriptive reports on a regular schedule. (Small groups may select plots at various locations throughout the community for a more diverse report.)

F. Materials of Earth are used and reused by plants and animals in the cycle of living things.

Discuss the following types of questions:

1.) What happens to the bodies of organisms when they die? (Decomposition by bacteria, etc.)

2.) If decomposition of organic matter did not occur, how would Earth's surface appear? (Theoretically it would be covered with bodies; bridges and tunnels would be necessary to get around or over the bodies. Actually this could not occur because the recycling is necessary in order for life to continue.)

3.) Is it possible for a natural resource such as iron to be "used up" without using up all the atoms of iron? (The idea is that iron atoms would still be available in the same amounts but not in sufficient quantity in one place to make mining a profitable adventure.)

Read the book *Lives of An Oak Tree,* by Ross E. Hutchins, Rand McNally and Company, Chicago, 1962.

II. All phenomena are interrelated within the environment. Interrelationships of matter and energy determine the characteristics of the environment.

A. Force results when matter interacts.

1. Force has magnitude and direction.

Tie a string to a small wooden block, and attach the other end of the string to a spring balance. Attach another piece of string to free end of balance. Pull this piece of string, and measure the magnitude of the force by the scale on the balance. Change the direction of the pull and the block of wood will change its direction of movement. Change the size of the wooden block to measure a different magnitude of force.

2. Force is necessary to change speed or direction of a moving object.

Roll an iron ball slowly past a strong magnet. How does the magnet affect the speed and/or direction of the rolling ball?

Ride a bicycle on the schoolyard or blacktop area. Is a force necessary to change the direction of the bicycle? Is a force necessary to stop the bicycle?

Roll two steel balls toward each other. Observe the results when the balls hit. Change the speed and/or direction and observe results. Place a sheet of carbon paper between two sheets of white paper and roll the balls across the paper so that they hit. Observe the trace of the paths on the bottom sheet of paper.

3. Many forces act upon an object (matter) from many directions at the same time; and the overall effect is a combination of these forces.

Place a child in a chair. Have a second child push the chair from the back while a third child pushes the chair from the side. Note the direction the chair moves.

Attach spring balances to two adjacent sides of a wooden block. Pull on the strings attached to the balances and note the magnitude of pull on each and the resulting direction of motion of the wooden block.

4. Force may be detected by the effect it has on matter. Sometimes force is present but too weak to be measured.

Use a hammer to pound on various materials such as a piece of soft iron, a block of wood, or a lump of clay. What evidence is observable as to the effect of the force?

Obtain several objects of different weight. Drop them from a pre-determined height. Can the different weights be identified by sounds heard?

Obtain a mass of clay and roll to about one inch thick. Drop a marble or small iron ball from measured heights in one-inch intervals moving the clay after each drop. What is the correlation between the height of the drop and the depth of the dent made in the clay?

5. Work is accomplished when a force moves an object (matter) through a distance.

Push a five-pound object a distance of one foot. (Five foot pounds of work have been accomplished.) Push the five-pound object three feet. How many foot pounds of work have been accomplished? How is this concept of work different from the concept of work used in our daily conversations?

6. Matter can only gain or lose the force of momentum by interacting with the opposing force of other matter.

Balance a ball on a flat surface. Observe that it remains stationary. Now push the ball. What is the opposing force?

B. Friction is the result of two surfaces coming into contact as they move in opposing directions, or in the same direction at different speeds.

1. Friction produces heat.

Rub two blocks of wood together. Touch the surface. Rub a piece of wood briskly with sandpaper. Touch the surface. How did Indians use friction to start fires?

2. Friction may produce static electricity.

Rub a rubber pocket comb with a piece of wool. Rub always in the same direction. Hold it near tiny bits of paper. See how many kinds of paper and bits of other materials the comb will attract. Be sure to rub the comb with the wool before testing new materials.

3. The nature of the surfaces which are in contact determines the amount of friction.

Obtain a piece of fine sandpaper, a rough piece of stone, a rough board, a mirror or a piece of glass, and some fluffy cotton. Rub the piece of cotton across each of the rough surfaces. What happens? Now rub the piece of cotton across the glass or mirror. Is any cotton torn away? Now rub your finger across each surface. Which surface will produce the most friction?

Obtain a book, a paper clip, a thin rubber band, a ruler, some cellophane tape, a rough board or sheet of sandpaper, and a smooth desk top or a pane of glass. Fasten the paper clip to the edge of the book. Then slip the rubber band on the clip. Fasten the ruler to the book with cellophane tape. The beginning of the ruler should be just at the end of the rubber band. Put the book on the rough board or sandpaper. Pull the rubber band very slowly and watch the rubber band stretching. How far has it stretched when the load begins to move? Make a note of the distance. (The stretch of the rubber band tells something about the force needed to overcome friction and move the load. The greater the force, the more the stretch. Now put the book on the smooth surface and try again. Is the same force, more force, or less force needed?

4. Friction can be used in controlling motion.

Ride a bicycle slowly on the blacktop. If the brakes did not work how would you stop the bicycle? Would dragging your feet produce friction? How can you tell that friction is produced?

Visit an automobile repair shop. Ask the mechanic to show the brake system of a car. Does friction help control the motion of the car? How is friction reduced at various places? What materials are used in the car to increase friction at some places and to decrease friction in others?

5. Friction can be reduced in many ways.

Fill a small box with blocks or other objects. Attach a string to the box and pull it for a measured distance across a rough surface and a smooth surface. Place pencils under the box and pull it through a measured distance. Place the box on a wheeled object, such as a toy wagon, and pull through the distance. Order the difficulty of the task from easiest to hardest. If the amount of pull were measured each time with a spring balance, show the results in a graph. (Friction may also be reduced by lubricating the surfaces which are in contact with oil as in many machines.)

C. Magnets will attract some types of matter but not others.

Experiment with magnets and a large variety of materials. Make a chart showing materials attracted by magnets. Make generalizations about results.

Make a list or display of devices in which magnets are used, such as magnetic bulletin boards, magnetic pencils, trays in cars, magnetic catches on cabinets and refrigerators, potholders with magnets, magnetic checkerboards, magnetic darts, and magnetic tack hammers.

1. Natural magnets can be found on Earth.

Obtain a sample of lodestone or magnetite from a scientific supply house. Test the effects of the lodestone or magetite on a variety of materials.

2. Magnets exert the greatest force at their poles.

Place a bar magnet on a table and cover with a sheet of paper. Sprinkle iron filings on the paper. (A very interesting pattern develops as the iron filings come under the influence of the magnetic field. The filings form a map of the field.) Draw a picture of the results.

3. Unlike magnetic poles attract, like poles repel.

Suspend one magnet on a string from a fixture so that it can turn freely. Bring the end of a second magnet near one end of the suspended magnet. Repeat several times. Which ends of the two magnets attract? Which repel?

4. A magnetic field (force) surrounds a magnet.

Bring the like poles of two bar magnets near each other under the paper sprinkled with iron filings as in Interrelationships II-C-2. (The repulsion of their lines of force is shown.) Draw the resulting pattern.

5. A magnetic force can act through some materials.

Obtain a variety of materials such as different kinds of cloth, paper, cardboard, glass, acetate, and aluminum foil. Test with various kinds of magnets the degree to which magnetism can act through the substance to attract magnetic materials.

6. Magnets can become demagnetized when their molecules are rearranged.

Use reference materials to determine what theories have been advanced about the nature of magnetism. After determining this can you infer what will demagnetize a magnet?

Magnetize two steel sewing needles by stroking from end to end with one pole of a magnet. Be sure that strokes are only in one direction. Test to see if the needle has become magnetized. Hold one needle with a pair of pliers and place in a flame for 3 or 4 minutes. Strike the other needle with a hammer several times. Test both needles to see if they have become demagnetized. What conclusions can be drawn from this test?

D. Magnetism and electricity are interrelated.

1. When electricity passes through a wire, a magnetic field is developed around the wire.
2. Electromagnets can be made by wrapping a wire into a coil around a bar of soft iron.
3. When the wires of the electromagnet are connected to an energy source, electric current flows through the coiled wire making a magnet.
4. When the electric current ceases to flow, the magnetic field disappears.

Construct an electromagnet by wrapping insulated copper wire about twenty times around a large iron nail or spike. Remove the insulation from the ends of the copper wire. Attach one end of the wire to one terminal on a dry cell. Touch the other end of the copper wire to the other terminal of the dry cell. (Do not connect both wires to the terminals as continued flow of current will exhaust the dry cell.) As the wire is touched to the terminal see if the nail will attract magnetic materials. Observe the results when the wire is removed from the terminal. (The nail can retain magnetism for a period of time after the wires are removed from the terminal, especially if it has been used several times.)

III. All phenomena are interrelated within the environment. Interrelationships between the atmosphere, the hydrosphere, and the lithosphere result in the ever-changing topography of Earth.

A. Weather is the result of interrelationships between a variety of factors such as temperature, pressure, wind speed, wind direction, and moisture.

1. Interaction between a mass of warm air and a mass of cold air determines the force of wind.

Build a convection box by removing the top and one side of a shoebox. Cover the side opening with glass, acetate, or cellophane, and tape securely on all sides. Cut two holes (1½ inch in diameter) from the bottom near the ends of the box. Place the box open top-side down over a lighted candle so that the candle is visible through the window, and is directly under one of the holes. Place a lamp chimney over each hole. Hold a smoking material over the lamp chimney without the candle under it. Observe the smoke. How is this convection current similar to winds on Earth?

2. Clouds and precipitation in various forms result from interaction of moisture, pressure, and temperature in the air.

View a movie on weather which illustrates the interaction of factors to produce clouds and precipitation.

Collect weather maps for a week from the newspaper. Paste the maps in chronological order on a long strip of paper. Examine the maps and try to determine changes in temperature, precipitation, and air pressure from day to day at some place in the United States.

3. Interaction between unusual atmospheric conditions may result in dramatic weather conditions such as hurricanes, tornadoes, blizzards, glaze, and hail.

Study weather maps from the newspaper to determine atmospheric conditions which produced a dramatic weather condition in your area.

4. The sun is the energy source for movements of air and water in the hydrologic cycle.

5. Water moves through the cycle of evaporation, condensation, and precipitation as a result of interactions involving temperature relationships.

Fill a heat-proof glass container with water and heat until the water is boiling. Place a pan full of ice cubes several inches above the container of boiling water. Observe the miniature water cycle which develops. How does the heat in this experiment compare with the sun in the cycle of evaporation, condensation, and precipitation?

6. Precipitation may be in a variety of forms:
   a. rain
   b. snow
   c. sleet
   d. hail

Catch snowflakes on a dark wool cloth and observe with a magnifying glass.

Collect hailstones during a hailstorm. Quickly cut them in half to observe the layers which have accumulated as the hailstone is tossed up and falls down in the air. Compare to layers of an onion.

7. Dew point is the temperature at which condensation of water vapor occurs.

Fill a shiny metal cup or tin can with water and ice cubes. Place a thermometer in the water, and record the temperature at which water droplets condense on the outside of the container. Record room temperature. Where did the condensed water droplets come from? Did each group performing the activity get the same results? What variables might account for any differences? Would results be different if a drinking glass or beaker were used instead of the metal cup? Try it.

B. Climate is the average of weather conditions over a long period of time.

1. Average temperature is a basic factor in the climate of an area.

Obtain information about average temperatures for various areas in the United States. Compare the average to the high and low temperatures.

2. Climate is affected by the topography of an area.

Study the effects of various land features such as mountain ranges, large plain areas, or bodies of water in relation to average temperature, high and low temperatures, and rainfall.

3. Ocean currents may affect climate by bringing moisture to an area.

Chart major ocean currents on a world map. Compare average temperatures, high and low temperatures, and rainfall of cities or areas near the ocean currents to those of cities at the approximate same altitude and latitude which are away from the effects of the ocean. Note the latitude of Great Britain. Use references to find data about its climate. Discuss relationships observed or inferred.

4. Altitude and latitude influence climate.

Secure several world maps. Form class committees of three or four children. Have each committee select a city to study. Have these selected cities well dispersed throughout the world. Use maps, globes, an atlas, encyclopedia, and other resources to find information about the climate of the city. Arrange data from all committees on a chart or make other visual presentations. (Needed information would include such factors as average temperature, highest temperature, lowest temperature, altitude, latitude, rainfall, prevailing winds, adjacent bodies of water, and other physical features.)

Investigate plant growth at various latitudes and altitudes as indicators of climate. Infer factors which affect plants.

C. Natural forces operating through millions of years have resulted in the deposit and formation of Earth's natural resources such as oil, coal, soil, and mineral deposits.

View a film and study reference material about the formation of coal or oil.

Look at geologic maps of areas that were once water-covered, and compare to sites of oil deposits.

IV. All phenomena are interrelated within the environment. Interrelationships appear to exist among all objects in the universe.

A. The sun is the ultimate source of energy for Earth.

1. The sun's energy is believed to be produced by nuclear fusion.

Use films, filmstrips, and other types of reference material to find various theories concerning the composition of the sun and the source of its light and heat.

Consult references to find the nuclear fusion reaction that is believed to take place on the sun. Illustrate this reaction with marbles, clay models, or drawings.

2. Sun provides Earth with light and heat.

Go outside on a sunny day. Stand in the sunshine, then in the shade. Describe the difference felt.

Blindfold one child and have another child lead him around the room on a warm day when the sun is shining in the window. Have the child being led tell when he is in the sunshine and when he is not.

Obtain two glass jars. Cover one jar with black paper and the other with white paper. Place a thermometer in each jar and set them in the sun. Read the temperatures every five minutes and record the results on a graph.

Obtain a large ball and place it in sunlight. Attach two thermometers to the ball with one on the side in the sun and one in the shade. Observe the light coming from sun to Earth. After a short time, compare the temperatures of the two thermometers.

Use a magnifying glass to focus the sun's rays on a piece of crumpled tissue paper placed on a tin pan or saucer. Observe as the paper bursts into flame. *BE CAREFUL.*

Keep written records of time and temperature measurements hourly for several days. Prepare charts to determine if a decrease in temperature occurs at approximately the time of sunset or just before sunrise. What part of the day produces highest temperatures, and lowest temperatures? Observe patterns in the readings.

3. Day and night result as Earth rotates on its axis.

Shine a lighted flashlight on a globe and explain that this represents the sun shining on Earth. Rotate the globe counterclockwise. Notice that the sun still shines, but not on the same area of the globe. Find the approximate location of the school on the globe, and fasten a paper doll at that location. Rotate the globe from west to east. (When the flashlight no longer shines on the doll, night has arrived. As the doll appears again on the other side of the globe, morning has come.)

Hold a flashlight representing the sun in front of the globe. Rotate the globe from west to east. Which state sees the sunrise first, Virginia, Texas, or Oregon?

4. A year on Earth is equal to one revolution around the sun.
5. Seasons are the result of the interrelationship of the revolution of Earth and the tilt on its axis.

Consult *Using Maps and Globes K-7,* Elementary Education Service, State Department of Education, August 1969.

6. Earth-sun relationships create life support conditions on Earth.

Write stories and draw pictures of Earth's appearance if the sun's energy did not reach Earth's surface.

Show a film about the energy of the sun. Discuss questions such as:

1. What would happen to Earth if the sun quit shining?
2. Would we be able to see the moon and other planets?
3. What changes occur at night on the side of Earth turned away from the sun?
4. What changes occur as Earth turns and sunlight is available?
5. Why don't we feel heat from the light of other stars at night?

Use reference materials to gather data. List the variety of interrelationships of Earth and the Sun. Develop models to communicate data obtained.

B. Moon is a natural satellite of Earth.

1. The moon orbits Earth in about one month.

Observe the phases of the moon. Record observations verbally and pictorially for a month. Compare with standard calendar.

Observe and record the time the moon becomes visible and disappears below the horizon daily for one month. Local airports, weather bureaus, or radio stations may be of assistance in this activity.

Take photographs of the moon at the same time each night for a month. Place the pictures in sequential order and display them.

2. The moon is visible because it reflects sunlight.
3. Phases of the moon result from interaction between the moon, Earth, and sun.

Put a mark on one side of a ball to represent the side of the moon turned toward the Earth. Ask a child to represent Earth. On one side of a darkened room place a strong light, such as a strong flashlight or projector, to represent sun. Revolve the ball about the child, keeping the marked side turned toward the child. Keep the light on the ball as it moves around the child. Stop at different positions and have child representing Earth describe what is seen. (The room must be very dark for good results.)

Observe the moon through a telescope. (A pair of binoculars will do, if a telescope is not available.) Mount the telescope or binoculars on a post or tripod. If neither post or tripod is available, hold the instrument against the corner of the building. Keep it steady. Study the moon's surface features. Observe the moon at various phases. The terminator will reveal different features at different phases of the moon. Identify by name the various plains and the major craters by referring to a good moon map. During observations of the moon, record the dates on which the various phases occur. Compare data with information in an almanac. Note the position of the moon among the major stars of the constellations at the same hour each night. Plot these positions on a star map.

4. Eclipses result from relative positions of moon, Earth, and sun.

Darken the room completely. Use a lighted lamp, a flashlight, or projector to represent the sun. Use a large ball or globe for Earth and a tennis ball for the moon. With Earth between the sun and moon, a lunar eclipse occurs, as Earth's shadow falls on the moon. With the moon between Earth and the sun, a portion of Earth is covered by the shadow of the moon resulting in a solar eclipse.

C. Other planets exert a force on the Earth as they rotate about the sun.

Use reference materials to study factors that lead to the prediction of the planet which is known as Pluto.

V. All phenomena are interrelated within the environment. Man must learn to live in harmony with interrelationships in the universe and his activities should enhance, rather than imperil, interrelated natural conditions.

A. Natural resources are interrelated, and the use or misuse of one will have an effect on others.

1. The size and range of species and populations are determined by interrelationships of biological and physical factors.

Refer to Interrelationships I-A, B and C; Equilibrium I-A and B; Change I-A-2 and B; Organization I-A-1, 2 and 3; and Space I-A and B. Perform activities suggested and interrelate ideas.

Select various plants and animals to study. Consult reference materials to determine the range of these organisms. Sketch the range on maps. What environmental factors within the range are similar? What dissimilar environmental factors within the range suggest a wide range of adjustment capability on the part of the organism?

2. One of the interrelated components of an environment such as space, water, food, or air may become a limiting factor to various life forms.

Refer to Change I-A-2-d, e, f, h, and B, and Interrelationships I-B, and perform activities suggested. Relate needs of living things to environmental conditions.

3. Man may disturb the interrelationships of Earth's natural resources through misuse causing depletion of particular resources, detrimental effects on various life forms, and pollution of air, water, and soil.

Refer to Change V-D; Equilibrium V-B, C, and D; Motion V-A, and C; and Space V-B.

Obtain water samples from a creek before and after a heavy rainstorm. Place the labeled containers in a safe place for several days. Measure the amount of silt which settles out of the water. How may man's activities increase silting and deposition? How would heavy silt content affect life in the creek?

B. Man is interrelated with the area in which he lives in terms of employment, life-style, recreation, and other aspects of his life.

1. Interrelationships of labor, capital, natural resources, and technology produce needed goods and services.

Refer to: *Elementary School Economics Guide*, State Department of Education, September, 1967, Section on Production of Goods and Services.

2. The relationship between man and the natural environment is mediated by his culture.

a. Supply and demand and the values of society determine what materials are resources and the relative economic value of each.

Investigate the relationship of various tribes of American Indians to their natural world. How did their life-style make them early conservationists or environmentalists? How were their various religious beliefs related to the natural world?

Determine why table salt was a very prized natural resource during colonial days? What other resources were highly prized? How have these changed with advancements in technology? What resources highly prized by people in other countries are taken for granted by Americans?

b. The material wealth of a nation is interrelated with its uses of nature resources.

Refer to Organization V-A-1 and Time V-B.

Determine which countries are considered very advanced and the natural resources which have helped to make the country wealthy. Study the distribution of the wealth among the people of these nations as illustrated by their standard of living.

c. Conservation practices are influenced by public opinion.

d. Social values and mores are the greatest influence on personal conservation behavior.

Refer to: *Man and His Environment*, State Department of Education, November, 1971.

Refer to Variety V and Adaptation V-C.

3. With expanding population, increased leisure time, and rising levels of consumption, man's need for food, fibers, and minerals will increase.

   a. The welfare of people in an area may be dependent upon maintaining, improving, or restoring soil productivity.

Obtain two plants of the same size. Place one in a container of rich soil (prepared potting soil) and the other in a container of poor soil. Water regularly. Measure plants weekly over a period of several weeks. How does soil quality relate to plant growth? What procedures can be employed to improve soil productivity on lawns and farms?

   b. Outdoor recreation is an important influence on our culture and economy.

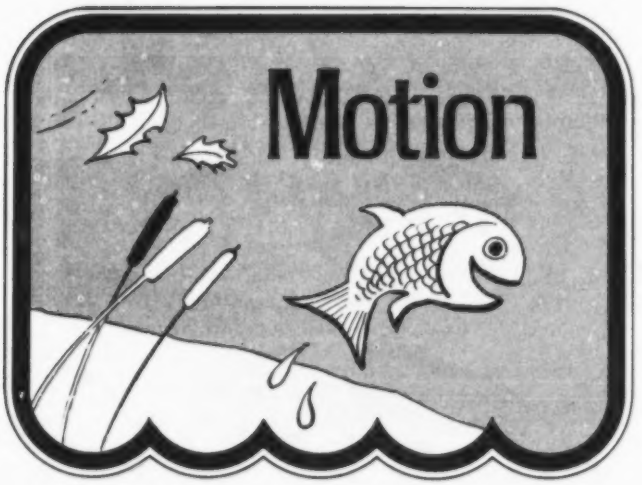
Determine the types of outdoor recreational activities available in your local area.

Survey the children to determine the types of preferred recreational activities and list the different kinds of equipment owned by the children and their families. Prepare graphs and pictorial displays of the results of the survey.

C. Natural resource policies, as well as other national policies, are the result of interrelated social processes such as science and technology, government operations, private interest, public attitudes, and aesthetic, ethical, and economic considerations.

   1. Management of natural resources results from application of technical and scientific knowledge toward specific objectives.
   2. Interrelated knowledge from many disciplines is applied in a program of environmental management.
   3. Social and technological changes may alter the interrelationships, importance, and uses of natural resources.
   4. Responsibilities for natural resources and environmental improvement are shared by individuals, business and industry, special interest groups, and all levels of government and education.

Refer to Adaptation V-C; Change V-B and C; Equilibrium V-C and D; Motion V-A; Organization V-C; Space V-C; Time V; and Variety V.



MOTION is the act or process of moving, or of changing place or position. Whatever its form, motion requires an energy exchange; that is, energy is expended or absorbed. Motion usually brings about a change in temperature, location, or direction.

Water flowing in a stream, a bird flying through the air, a marble rolling across the table, or clouds moving across the sky are observable motions. The rotation of Earth on its axis, the revolving of Earth around the sun, the movement of molecules, and electrons spinning around the nucleus of an atom are motions which are not readily observable.

The migration of some birds and other animals is a form of motion which occurs with a degree of regularity, as does the revolution of planets. Other evidences of motion such as flood, tornado, or lightning streak are not regular.

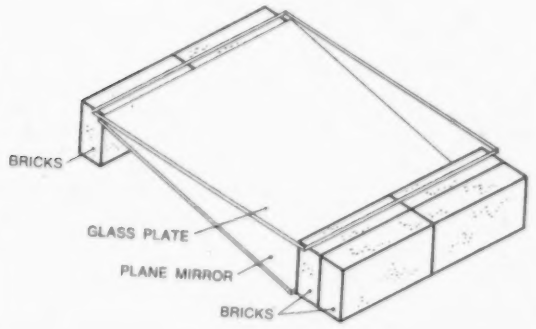
MOTION

I. Matter is in constant motion. Living things and the components of their cells are in motion.

A. Many living things have observable motions.

1. Living things move in a manner appropriate to their life style.

Obtain six bricks, a piece of flat clear glass, and a large plane mirror. Place two bricks end to end on one side of a table. Place the other four bricks with two end to end and two deep. Place the mirror with one end raised on the two bricks and the other touching the table surface next to the four bricks. Add the glass plate over the opening between the bricks. Place sow bugs, ants, earthworms, or other creatures on the glass plate. Observe their movements from above and from below as they are reflected in the mirror.



Observe the different ways animals move around by such activities as having a pet show in classroom, visiting a farm, a fish hatchery, or a zoo.

Plant seeds in jars to observe root growth and movement in the soil.

Show films of various animals to view various forms of movement. If possible, show film in slow motion. Turn sound off in order to concentrate on motion.

Play games in which children imitate animal movements while others guess the animal.

2. The motion of living things may be affected by such external forces as:

a. Wind

Plan field trips in autumn to observe the ways seeds are moved from place to place.

Observe birds flying on windy days.

Go outside on a windy day. How does walking on that day compare with walking on a quiet day?

b. Gravity

Perform activity in Adaptation I-B-1-b.

Stand on a chair. Jump off. How did gravity affect motion? Try to broad jump as long a distance as possible. How did gravity affect the distance?

c. Light

Perform activity in Adaptation I-B-1-a.

Investigate activities of nocturnal animals such as raccoon, oppossum, and fox.

Use a magnifying glass to study planaria. Why are these animals called light-negative? Place planaria in water in a container which has a light end and a dark end. At which end do the animals gather? Is the light also associated with temperature?

d. Temperature

Place a cold-blooded animal nsect, amphibian, or reptile) in a covered con er. Put the container in a bucket of cold wate ice cubes. (Use caution to prevent suffocation or drowning of the animal during the time required for a change in behavior.) Observe the animal as the air around it cools. Remove the container from the ice and observe the animal as the air around it warms. (The container might be placed in a refrigerator for 10-30 minutes rather than using ice if desired.)

Refer to Interrelationships I-B-2.

e. Water

Perform activity in Adaptation I-B-1-c.

Visit a stream to observe the movement of animals in a quiet part of the stream and in a more rapidly moving part of the stream. Place a toy boat in the stream and follow its journey. How were the reactions of the animals to the moving water different from that of the toy boat?

B. Materials essential to life move through the cells and bodies of living things.

1. Cells absorb materials from their surroundings and release wastes into their surroundings.

Fill a test tube one-eighth full of red ink. Cover the opening of the test tube with permeable plastic food wrap held secure by rubber bands. Invert the tube in a beaker of water. Allow the apparatus to stand several hours. Observe results. How is the food wrap similar to a cell membrane? How is it different?

2. Essential materials are distributed by vascular tissue in many plants.

Place a stalk of celery, daffodil, or other light-colored flower in a beaker of colored water. Allow to stand for several hours. Observe results.

3. Essential materials are distributed by the circulatory system in many animals.

Study a simplified circulatory system of several higher animals. Note the relationship of the system to other major organs such as lungs, kidneys, liver, and stomach.

View a film which illustrates materials moving through the circulatory system.

C. Atoms and molecules composing living things are in constant motion.

Refer to Motion II-A.

II. Matter is in constant motion. All forms of matter and energy involve movement.

A. Molecules of matter are in constant motion.

Fill a test tube about one-fourth full of alcohol. Add a small amount of chalk dust. Place thumb over the mouth of the test tube and shake thoroughly. Use a medicine dropper to place a drop of the solution on a microscope slide. Observe under low power with good light. Try to follow the motion of one particle of chalk dust. (Point out that the motion of the dust is representative of the motion of molecules, rather than true molecular motion.)

Fill a glass three-fourths full of water. Allow it to come to room temperature. Gently add several drops of food coloring to the water. Observe the diffusion of the coloring through the water for the next few days. (Be certain to keep the glass out of the sunlight, and away from vibrations which might alter the diffusion. The mixing of the two solutions is the result of molecular motion.) Would there be a difference if coloring were added to a jar of hot water and a jar of cold water? Try it and compare results.

Open a bottle of ammonia, perfume, peppermint oil, or some other liquid which has a strong odor. (As molecules evaporate students will smell the odor because the molecules reach the olfactory nerve.) Ask students to raise their hands when they smell the odor. This may be put onto a graph showing time and distance, if a clock is available.

Keep a chart for several weeks during which children try to guess the lunch menu based on odors of the cooking food. Do not peek at the menu prior to the guesses.

Collect various items with characteristic odors. Number the containers and identify the substances based on odor.

1. Molecules of solids:
   a. are closest together,
   b. have greatest mutual attraction,
   c. have lowest energy content, and
   d. thus, have the least motion.
2. Molecules of liquids:
   a. are less close together,
   b. have less mutual attraction,
   c. possess more energy, and
   d. thus, have more rapid motion.
3. Molecules of gases:
   a. are least close together,
   b. have least mutual attraction,

c. possess most energy content, and

d. thus, are in most rapid motion.

COMPARATIVE CHARACTERISTICS OF THE THREE STATES OF MATTER

Char. State	Distance Between Molecules	Mutual Attraction of Molecules	Energy Content of Molecules	Degree of Molecular Motion
Solid	Closest together	Greatest	Least	Least
Liquid	Less close together	Less	More	More
Gas	Least close together	Least	Most	Most

Make a pyramid of sugar cubes in which the cubes represent molecules of a solid. Move the pyramid across the table top. Does it seem fairly stable? Is there much space between the molecules? Does the pyramid retain its size and shape?

Pour BB shot in a petri dish, saucer, or other container to form a pyramid. The BB shot represent molecules of a liquid. Gently move the dish containing the pyramid across the table. Does the pyramid seem fairly stable? Compare the stability to that of the sugar pyramid. Is there much space between the molecules? Could you move the BB pyramid had it not been in a container?

Cover the bottom of a beaker, glass corn popper, or other heat-proof, clear glass container with vegetable oil. Add enough popcorn to make a layer one kernel deep. The popping corn, while moving, will represent molecules of a gas. Place a top on the container and put over medium heat from bunsen burner or hot plate. Observe the motion of the popping corn. Why was the cover needed? Compare the space between molecules of solid, liquid, and gas. (Remove container from heat before burning the popcorn. Be careful not to burn yourself).

Put marbles one layer thick in a small, flat cardboard box. The marbles represent molecules of a solid. Slowly move the box back and forth across a table. Observe the motion of the marbles.
Remove one third of the marbles from the box used above. Move the box back and forth across the table more rapidly than before. Observe the motion of the marbles. What state of matter is represented?

Remove another third of the marbles from the box used above. Move the box more rapidly back and forth across the table. Observe the motion of the marbles. What state of matter is represented?

Now cut out several holes in the sides of the box. Make the holes larger than the diameter of the marbles. Now repeat the rapid back-and-forth motion of the box of marbles. What change is observed with the holes in the sides of the box?

B. Heat energy content of molecules (molecular motion) may be increased through the use of other forms of energy.

Ask a doctor or nurse to discuss diathermy as a medical treatment.

Investigate the way in which radar ovens cook food.

1. Changing the amount of heat energy content (molecular motion) may change the state of matter.

Place some ice cubes in a pan with a thermometer. Record the temperature at regular intervals as the ice melts. Then place the pan on a hot plate and heat to boiling. Record temperature at regular intervals until the water boils rapidly and steam is seen to rise. Relate this experience to the water cycle.

2. Different kinds of matter require different amounts of heat energy to change their state.

Consult reference materials to find the melting point of various metals such as iron, copper, or aluminum.

Consult reference materials to determine how anti-freeze functions and why salt is used on icy streets.

III. Matter is in constant motion. Earth's atmosphere and hydrosphere are in constant motion.

A. Water moves in a dynamic cycle through the atmosphere, lithosphere, and hydrosphere.

Obtain two similar dishes and fill each with a cup full of water. Put one dish into the refrigerator, the other under a lamp. After two days compare the amount of water remaining in each dish. Measure the amount of water left in each dish with a measuring cup. (When the temperatures are low, molecules of water are moving slowly, hence colliding with each other at slow speeds. This action bumps some of the liquid into the air; however most of the particles remain in the dish. The experiment is comparable to what is happening outdoors at a

pond, lake, or ocean. The sun's rays are absorbed by the water causing the water to become warmer. This increases the speed of evaporation. Water molecules leave the pond and enter the atmosphere.)

Prepare a bulletin board or other visual display of the water cycle.

Refer to Motion II-A, and B.

B. Water of Earth's hydrosphere moves in vertical and horizontal currents.

Make paper boats and take them to a nearby stream. Put the boats in the stream at different places and observe the direction in which the boat moves.

Study maps of major ocean currents.

Refer to Motion III-D.

Use reference materials to study about the turnover of water which occurs in ponds or lakes as the winter ice melts.

C. Atmospheric circulation causes changes in weather.

Use reference materials to study the various belts of prevailing winds which affect Earth.

Study weather maps over a period of time to note movement of pressure areas and the resulting weather changes.

D. Temperature differences set up conditions for movement in the atmosphere and hydrosphere.

Pour some cold water into a beaker or other heatproof, clear glass container. Gently add some saw dust or a few drops of vegetable coloring to one side. Heat one side of the beaker. Observe results.

Read about convection currents in reference materials.

IV. Matter is in constant motion. Objects in the universe exhibit motion.

A. Earth's motions in the solar system are measured in time and seasonal changes.

Use a sextant to show how stars change position in relation to Earth due to Earth's rotation and revolution.

Use a globe and film projector to demonstrate the occurrence of day and night. Use a globe inclined 23½° and a light source to show relative positions of Earth and the sun during the year. (Point out that sunlight covers a greater area during winter than during summer due to the tilt of Earth.)

Refer to *Using Maps and Globes*, Elementary Education Service, State Department of Education, 1969.

B. Relative motions of the sun, moon, and Earth bring about tides, eclipses, and phases of the moon.

Make a series of models showing the phases of the moon. See if the class can learn to identify the correct position of the moon in each phase.

Use a flashlight, a globe, and a rubber ball to illustrate a solar eclipse, a lunar eclipse, and the phases of the moon. See Interrelationships IV-B-4.

Demonstrate tides by constructing the following model. Obtain a piece of white paper board 18″ x 24″, a roll of absorbent cotton, a bottle of blue ink, and some glue or household cement. On the poster board draw a circle six inches in diameter and paint the word "Earth" inside the circle. Roll and shape some absorbent cotton until it looks like a doughnut three inches thick. Fit the cotton around the circle and glue the cotton to the poster board. After the glue has set, pour the blue ink on the cotton to give the effect of blue water. Tape the poster board securely to the chalkboard. Cut out a paper circle three inches in diameter and write the word "Moon" on it. Tape the moon to the chalkboard to the right of Earth. Gently pull the cotton on the side of Earth nearest the moon. (A bulge that shows the formation of a high tide will form.) Gently pull the cotton on the side farthest from the moon to produce a second high tide. (The top and bottom of the cotton circle will flatten out to form two low tides.) To show spring tides and neap tides, cut out another circle and write the word Sun on it. Place the sun to the right of the moon. Create a spring tide effect with the cotton. Place the sun above Earth at right angles to the moon and create a neap tide effect with the cotton.

Blow up a large balloon several times to stretch the rubber. Fill the balloon with water and tie the neck securely with a string. Holding the balloon in your left hand, with the neck to the right, quickly pull the neck of the balloon in a horizontal direction with your right hand. What happens to the opposite side of the balloon? How does this illustrate the effects of the moon on tides? (Repeated efforts may be necessary to obtain effect.)

C. Gravitation and inertia control the movements of planets, satellites, and rockets.

Refer to Equilibrium IV-B.

Make a mobile showing the movement of planets around the sun.

Use a classroom globe and toy planes to show that when a plane goes up it goes away from Earth; when it comes down it goes toward Earth.

D. The solar system moves within the universe.

V. Matter is in constant motion. Man must learn to live in harmony with motion, and his activities should be compatible with natural motion.

A. The distribution and location of natural resources in relation to economic, technological, and population factors are important aspects of resource conservation and use.

1. Man's increased mobility is changing the nature of demands on some resources.

Prepare a bulletin board display depicting technological developments which have fostered increased mobility.

Use resource material to obtain population figures for various areas for the last 50 or 100 years. Prepare a chart, labeled map, graphs, or other visual display of the changing distribution figures.

Determine basic resources necessary to meet life needs and relate to changing population distribution.

2. Changing population distribution is causing man to use technology to make some resources such as water available in sufficient quantity and of acceptable quality.

Identify the water sources for your community and those in adjacent areas. Are the sources different? How is water quantity and quality controlled?

3. The political and economic strength of a country is dependent, in part, upon access to foreign and domestic resources and international trade.

Identify sources of various resource materials for the United States such as natural gas, oil, copper, and bauxite. Which resources are dependent upon international arrangements? How may world politics affect the future sources of these materials?

B. World-wide circulation of water and air makes attention to their quality extend beyond political boundaries.

1. Atmospheric circulation distributes particulate matter, carbon monoxide, radio-active fallout, and some disease-causing organisms.

2. Circulation of water also carries some of these same materials in addition to other wastes from agriculture, industry, and home.

Study diagrams and films of world-wide atmospheric circulation, and major ocean currents. Why are international treaties or agreements necessary with respect to atomic testing and pollution?

C. The surface of Earth is constantly modified by natural processes of erosion and deposition.

1. Man accelerates the rate of erosion processes in such activities as deforestation, strip mining, and excessive cultivation of soil.

2. Man accelerates the rate of deposition processes by such activities as draining and filling swamps and marshes, and sanitary land fills.

Refer to Change III A, B, and C for natural erosion and deposition.

Visit a man-accelerated erosion site and deposition site. What environmental considerations need to be given in each situation?

ALL matter and energy in the universe exist in patterns or systems consisting of sets of interrelated members. Organization might be viewed as the grouping of parts to form a whole, and the manner in which parts of the whole are arranged to work together. Evidence of organization ranges from the readily visible to that which is impossible to observe.

The difference between water as a solid and water as a liquid is readily visible; whereas, the solar system represents an organizational pattern which can be observed only in part. Other patterns such as the interaction of protons, neutrons, and electrons to form atoms are difficult or impossible to observe. Man has attempted to describe and explain these naturally occurring patterns of organization.

In other instances man has devised a pattern of organization for things which do not appear to be organized naturally. The systems of classification for plants and animals, the mapping of Earth's surface, and the descriptive names for the layers of the atmosphere represent an attempt by man to apply organization. The classification of events or situations is man's attempt to organize knowledge for greater understanding of natural phenomena.

ORGANIZATION

I. All phenomena exhibit systematic relationships. Living things are organized in terms of structure, function, life cycle, and other characteristics.

A. Man may describe organization in the environment.

1. The physical environment may be described based upon:
   a. altitude
   b. latitude
   c. pressure
   d. availability of water
   e. intensity of light
   f. chemical composition
   g. temperature

Identify plants and animals found locally. Group plants and animals according to the environment where they are found. Organisms to look for may include:

turtles	wildflowers
fish	trees
birds	shrubs
snails	vines
earthworms	herbs
insects	

Compare animals and plants of various environments. Make booklets, shadow boxes, collages, or posters about animals and plants from environments such as arctic, tropic, desert, and ocean.

Place a plant in dirt at the edge of glass bowl. Water the plant and wait for it to become accustomed to its new habitat. When well-rooted, water only on the side opposite the plant. Observe the path of roots every few days. Draw pictures to record observations.

Use films, filmstrips, pictures, and other reference materials to study the physical environment and its effect upon living things.

2. Animals and plants are sometimes grouped by the type of environment in which they live.

View film or filmstrip about life in a terrarium. Develop several different terrariums illustrating the environments that result from different combinations of factors. Examples include: desert, high mountain, seashore, forest, farm land, tropic, and marsh. Record observations in terms of what happens within each terrarium. Make inferences and compare results.

3. Living things which have some similar characteristics tend to live in similar environments.

Collect soil samples from a variety of places. Bring in several pails of rich soil from the area. (Dig deep—about four or five inches below the surface.) Examine the soil samples for animal life. Sift the soil through a piece of screen. Observe through magnifying glass and keep a record of the number and types of animals found in each sample. Compare the results with soil brought in from different locations, such as soil from base of a tree or the edge of the pond. (Each may provide a variety of specimens.)

Select classmates to form committees. Choose an environment to investigate. List the common characteristics of plants and animals which live in each environment. Devise methods of reporting findings to other class groups. (Selection of environments near the school will allow actual observation in addition to reading of reference materials.)

4. Man has attempted to group animals and plants according to similar characteristics.
   a. Biological classification is based on structural similarities.
   b. The means by which plants and animals meet life needs can often be inferred by observation of their external structure.

Play a classification game. Obtain five boxes. Label one box for each class of vertebrates: fish, amphibians, reptiles, birds, and mammals, and their characteristics as shown below.

Fish	**Birds**	**Reptiles**
cold-blooded	warm-blooded	cold-blooded
has fins and scales	has feathers	has scales or plates
lives in the water	lays hard shelled eggs	lives on land

Mammals	**Amphibians**
warm-blooded	cold-blooded
bears its young alive	smooth skinned
lives on land	lives in or near water

Gather and mount pictures of many animals representing all classes.

Classify animals by putting pictures in appropriate boxes.

Form class committees and ask each member to bring at least several pictures of animals. Separate the pictures into two divisions putting together all the animals that are alike in some way. Review results with the class. Discuss the criteria for classification. Some may be classified as animals with a backbone or as animals without a backbone. Determine ways to divide the large group of animals into smaller groups. Which animals should be grouped due to likenesses?

Get a medium-size fish from a local market. Examine the web-like structure of the gills that make possible obtaining oxygen from water. Expose this structure by spreading the gill slits. Examine scales of the fish. Use a magnifying glass. Note the slippery feeling of the body, an aid to moving through water. Investigate how the body structure enables the fish to meet his life needs. Observe live fish in the aquarium.

Take nature walks and bring samples of leaves from different trees. Compare structures of leaves: shape, size, veins, margin. Identify leaf with type of tree. Identify cone-bearing trees by shape of cones and leaves.

B. Cells in multicellular organisms are capable of performing special functions.

1. Living things may show organization in levels described as cells, tissues, organs, and systems.

Use a microscope to observe one-celled animals such as paramecium.

Open an onion and peel the thin tissue section from inside one layer. Place tissue on glass slide and stain with a solution of iodine. Place the slide on stage of microscope or microprojector. Identify calls parts.

Study models and drawings of various systems of the human body.

2. Parts of multicellular organisms are dependent upon other parts and cannot generally function or exist independently.

Invite a nurse or doctor to visit the class to discuss various functions of the human body. Which parts can be removed without bad effects? Which parts can be removed and mechanical or chemical processes substituted? Which parts are vital?

3. Generally the greater the degree of cellular specialization the more complex the organism.

Observe prepared slides showing muscle cell, nerve cell, and others that show how cells are organized into tissues. Relate the various kinds of cells found to the complexity of the organism.

Use reference materials to study about one-celled organisms (ameba or paramecium), slightly more complex (hydra or sponge), and a vertebrate. Compare the complexity of the various organisms based upon the degree of specialization of the cells.

4. Hereditary characteristics of living things tend to be transmitted according to identifiable patterns.

Observe specific characteristics of the young of certain animals and determine what characteristics the young have that are similar to those of the parents.

a. Certain traits are dominant over other traits.

Use reference materials to determine which traits in various plants and animals are dominant.

b. Hereditary traits are transmitted by DNA, a protein molecule of which chromosomes are composed.

Construct a model of part of the DNA molecule.

Relate the chemical code of DNA to other forms of code familiar to children.

c. In the process of cell division, chromosomes may be damaged in some way causing a mutation which changes the genetic code.

Study the process of cell division using films, filmstrips, and other reference materials. (Emphasize that this process is occurring in our bodies constantly, and that cells, though small, are the basis for all life processes.)

C. Some living things exhibit organization in life activities.

1. Organizational patterns in the growth and development of living things are described as the life cycle.

Compare the life cycle of man to life cycle of various animals (butterfly, frog, bird). Make inferences concerning similarities and differences. Make charts illustrating pattern of growth and development of these animals.

2. Living things exhibit a rhythm in the ways they carry on life processes.
   a. Sleep/wake cycle

Place a large cardboard box over an aquarium containing fish to simulate darkness. After a few hours, carefully remove the box. What fish, if any, seem to be resting? Where are they in the water—at the top, middle, bottom? Are any moving their fins? If so, which fins?

   b. Reproductive cycle as related to seasons

Choose an animal and make a study to determine how climatic conditions and time of year influence reproduction. (Animals such as bear, frog, birds, salmon, and bees may be chosen.)

Observe house plants growing under artificial lights and those under normal sunlight. Discuss the relationship of the blooming period under normal conditions and under artificial light. Which have blooms first?

   c. Feeding/elimination cycle

Observe feeding/elimination cycle in pets. Record data from observations.

Classify animals according to day or night feeding habits. Trace the food chain of several large carnivorous animals to the point where the smaller animal eats plants. Study the relationship of a time of feeding to the type of food eaten.

Refer to Time I-B.

D. Social organization exists among some animals.
   1. Populations tend to be organized into communities.

View the film "Ants—Backyard Science" available from State Film Library.

Observe a bee hive in the community.

Investigate populations of game animals that are found in Virginia. Information on these animals can be obtained from the Commission of Game and Inland Fisheries.

   2. Family relationships in higher animals differ with species.
   3. Specific examples of such organization are exhibited in colonies, flocks, and prides.

View a filmstrip on beavers. Discuss what they do in winter. Why do they move their homes? How do they contribute to pond community?

List important television programs pertinent to topics under study. Weekly revisions should be made based on available information. (A brief summary of the program can assist children in program selection.)

II. All phenomena exhibit systematic relationships. Matter and energy appear to exist in patterns or systems.

A. The electromagnetic spectrum is the organization of radiant energy according to wave length.
   1. Shorter wave lengths include gamma rays, x-rays, and ultraviolet light.
   2. Visible light can be broken by prisms into a color spectrum of violet, blue, green, yellow, orange, and red.
   3. Longer waves are used in broadcasting such as radar, television, and radio.
   4. These electromagnetic waves are similar to light waves in most ways.
   5. The longer wave lengths are lower in energy.

ELECROMAGNETIC SPECTRUM

MORE ENERGY Shorter Waves — LESS ENERGY Longer Waves

Name	Gamma Rays	X-rays	Ultra-Violet	Visible Light V-B-G-Y-O-R	Infra-Red	Radar	TV & Radio
Example	Astro-nomical Space	X-ray tube	Sunlamp	Lamps	Hot Iron Toaster	Radar Equip-ment	Broadcast Station

Investigate the properties of visible light.

Use reference materials to study the electromagnetic spectrum.

Make a bulletin board with pictorial illustrations of the various uses of radiant energy.

Visit a radio or television station. Ask about the broadcast frequency.

Ask local police or sheriff to demonstrate radar equipment used in auto speed control.

Ask a ham radio operator to visit the class and *demonstrate equipment.*

B. Matter may be described in terms of an organizational pattern.

1. Elements are the basic components of all matter.

Identify some of the elements found in Earth's crust. Classify these into the two major groups—metals and non-metals. What properties distinguish metals from non-metals?

2. The specific characteristics of atoms and molecules determine the special ways in which they combine to produce different compounds.

Draw triangles, squares, rectangles, and other straight-sided shapes on construction paper of various colors. Cut out shapes. Select several pieces of different colors and different shapes to use in forming a design. Rearrange the shapes to form another design. Add different pieces to form a third design. (Relate the different shapes and colors to different atoms and molecules and the various types of combinations which can be produced.)

3. The crystalline structure of some solids is characteristic of that matter, and may be used for identification.

Examine some table salt and sand grains with a magnifying glass. Look at a diamond with a jeweler's glass or magnifying glass.

Examine the crystals in various rocks and minerals.

4. Man has organized chemical elements according to similar properties in the form of a Periodic Chart.

Show the film "A Is for Atom" or some other film that is appropriate to the topic.

C. Generally matter exists in one of three states—solid, liquid, and gas.

1. The state of matter may be changed through application or removal of heat energy.

2. Solids have certain characteristics based on energy content.

a. Solids have a definite shape and volume.

b. Molecules of solids are relatively close together, have great mutual attraction, and relatively low energy content, and thus are in relatively little motion.

3. Liquids have certain characteristics based on energy content.

a. Liquids have a definite volume but take the shape of the container in which they are found.

b. Molecules of liquids have relatively slight mutual attraction, possess more energy, and have more rapid motion than molecules of solids.

4. Gases have certain characteristics based on energy content.

a. Gases do not have a definite shape or volume but assume the shape and volume of the container in which they are found.

b. Molecules of gases are much farther apart, have least mutual attraction, possess high energy content, and thus are in most rapid motion.

Refer to Motion II.

Examine some solids such as a piece of wood, a rock, and a piece of metal. Notice the definite shape and volume. Pour some liquid from a bottle into a saucer or pie plate. Notice the definite volume and changed shape. Use an air pump to inflate an inner tube until firm. Measure the air pressure with a gauge. Try to add more air and measure pressure. Note the air took the volume and shape of the inner tube. (If the inner tube and gauge are not available, use an air pump and playground ball. Check pressure by feeling firmness and bouncing the playground ball.)

III. All phenomena exhibit systematic relationships. Earth is composed of the atmosphere, hydrosphere, and lithosphere.

A. Man attempts to systematically explain Earth through various activities.

1. Maps of land and oceans are drawn in relation to parallels of latitude and meridians of longitude and physical features.

Locate Virginia on a map or globe. Identify the parallels of latitude and meridians of longitude which cross the state. Identify major physical features.

Consult *Using Maps and Globes*, State Department of Education, Richmond, Virginia, 1969.

2. Rocks and sediments are studied according to physical and chemical properties.

Use resource material to locate Mohs Scale of Hardness, or a simplified version of that scale. Bring in rocks and minerals and identify properties. Test rocks for hardness.

Ask local geologists to recommend an area which amateurs may explore. Plan an expedition to the area. Make a list of the various geologic features which should be observed.

3. Seismographic recordings are studied and interpreted.

Use reference materials to research the layers of Earth. Construct a model of Earth's layers.

Make a model of a seismograph using a shoe box, a magic marker, a cup hook, and a metal coat hanger. Stand shoe box upright with opening facing you. Make a small hole in center of top. Thread the curve of the hook into the box through the hole, being careful not to enlarge the opening. The small plate at the base of the hook will keep it in place. Use a pair of pliers to cut the length of wire from the coat hanger about two inches shorter than the shoe box. Curve one end into a hook. Hang the wire over the cup hook. Tape the magic marker to the opposite end of the wire. Position the marker so that it just touches the bottom of the box. Cap the marker until ready to use. Cut a slot across the back of the box at the bottom. Push a strip of paper through the slot so that it covers the bottom of the box. Uncap the marker and the seismograph is ready. While the seismograph is operating, pull the paper very slowly through the slot. Test the seimograph by placing it on a table. Rock the table back and forth gently. Note the pattern on the paper. Increase motion of the table. Compare the patterns. Try a variety of locations and methods for producing vibrations.

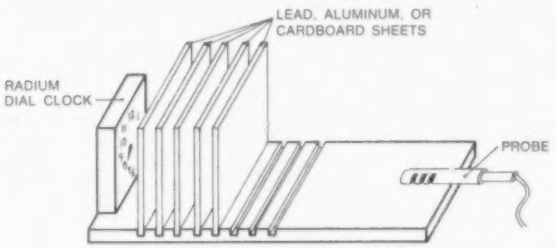
4. Forces such as radiation, gravity, and magnetism are studied.

Weigh such objects as a brick, balloon, block of wood, block of iron, or some other heavy metal. Note the relationship of the weight of each object to its size and shape.

Obtain a geiger counter, a clock with a radium dial, and pieces of iron, lead, and aluminum. (Geiger counters can usually be obtained from local Civil Defense chairman, high school science department, or Police or Fire Departments.)

Energize the Geiger Counter and probe the various materials listed above, listening for the clicking of the Geiger Counter. Bring the probe next to the radium dial of the clock. Describe results.

Obtain Geiger Counter, some aluminum sheets, cardboard squares, lead sheets, and a radium dialed clock or watch. Place the lead, aluminum, or cardboard sheets between the radium dial and the counter probe. Remove one shielding layer, then another. Describe results. Compare with sheets of different materials.



Have the radiologist from the hospital visit the classroom to discuss shielding of the x-ray machine. Ask that the apron and lead-lined gloves be brought for display.

5. Researcing of fossils, artifacts, and radioactive materials may establish a time sequence to the layering of Earth.

Use the fossils the children have to help piece together past time. For comparison older children can construct a time line of the geologic periods. Collect as many pictures as possible of important fossils.

Investigate the use of radioactivity to determine the age of rocks and fossils.

6. Knowledge of Earth and moon is used to develop greater understanding of the universe.
   a. Knowledge of Earth's structure, properties of matter, and gravitation is used to predict what might be found on the moon.
   b. Data and materials from the moon may help man to better understand origin of Earth and its natural history.

Read about the moon rocks and what has been revealed about likenesses and differences between the planet Earth and its satellite. Go to see the moon rocks, if possible.

Make models to compare the topography of the moon and Earth. Discuss the effects of erosion and the resulting dynamic changes that constantly occur on Earth as contrasted to the moon. Refer to Change III-A, B, and C.

B. Patterns and systems exist in the lithosphere.

1. The characteristics of Earth's crust are dependent upon the distribution of materials.

Ask a representative of the Soil Conservation Service or branch of the local government to discuss building codes in relation to soil and/or rock types. Include description of various techniques of soil/rock testing such as the perk test and coring.

Use resource maps of Virginia, the United States, and Earth to locate various types of materials in Earth's crust.

2. Earth's surface is mapped in a variety of ways according to definite plans to fulfill specific needs.

Refer to *Using Maps and Globes, K-7,* Elementary Education Service, State Department of Education, Richmond, Virginia, 1969.

Make a collection of maps of the same locality that illustrate different features of Earth such as physical features, political features, vegetation, rainfall, and population. Display on the bulletin board in order to make comparisons.

Construct three maps of one street, one showing the number of children in each home, another showing homes having pets, and the third, materials from which homes are built.

3. Land forms of Earth have been identified according to similarity of structure.

Use various maps to identify physical features such as continents, islands, peninsulas, rivers, mountains, and valleys.

4. Earth's crust is composed of certain basic materials which appear in numerous combinations.

a. Minerals occur in pure form and in various combinations as rocks.

Make a table of the chief elements that compose Earth's crust.

Make a graph showing the most abundant minerals and rocks on Earth.

b. Rocks are classified on the basis of their origin (sedimentary, igneous, or metamorphic).

Use reference material to classify various rocks as to their origin.

Determine the most abundant rocks found in Virginia. Locate the areas of large deposits on a map. Classify rock deposits on the basis of origin. What does the presence of sedimentary rocks tell about the geologic history of the State?

C. Patterns and systems exist in the atmosphere.

1. The atmosphere moves with and around Earth.

Use a rolled plastic garment bag representing the atmosphere to surround a globe. Rotate the globe under the plastic bag without moving the bag. If the atmosphere and Earth behaved in this manner how would our weather be different? Now rotate the bag with the globe. Is this more nearly the way the atmosphere and Earth function? (Specify that the gaseous atmosphere does not move in one mass as the bag does. This accounts for the varying weather patterns on Earth.)

2. Layers of the atmosphere are described according to observable data.

Construct a model or bulletin board display with the layers of the atmosphere. Include the characteristics of each layer and approximate altitudes.

Relate the concepts of gasses in Motion II to the atmosphere. Include the relationship of gases being dispersed throughout a container to the diminishing amount of gravity at distances farther from Earth.

3. Patterns within the atmosphere help man to predict changes in weather.

a. Atmospheric conditions such as temperature, humidity, and barometric pressure are measured and recorded on weather maps.

Clip weather maps and weather predictions over a period of two weeks. Note patterns of high and low pressures. Record the actual weather and compare with predictions.

View a film on the work of meteorologists.

Visit a weather station or the weather center at the local airport.

b. Long-term records and daily readings are used to predict weather conditions.

Announce a weather prediction over the school intercom for a period of time, or develop a weather predicting station on a hall bulletin board using maps and charts as follows:

Date	Temp.	Barometric reading	Barometric tendency	Relative humidity	Wind direction	Wind speed	Prediction

Make a chart displaying symbols discovered by studying weather charts. Label the symbols and indicate the meaning of each.

Ask children to bring two weather maps of consecutive dates from the same local paper. Select several cities and give the weather in these cities.

c. Cyclic weather patterns over long periods of time are called climate.

Consult an atlas, almanac, and other reference materials to determine such factors as average temperature, rainfall, humidity, and high and low temperatures for various cities in the United States. Post these figures on a map of the United States Relate these to geographic features.

Differentiate weather and climate.

D. Patterns and systems exist in the hydrosphere.

1. Approximately 75% of Earth is covered by oceans, rivers, inland lakes, and other bodies of water which make up the hydrosphere.

Use globes and world maps to identify major bodies of water. If possible, cut a world map into land areas and water areas. Compare area of water to area of land. Place the cut-out map of the United States over the Atlantic Ocean and over the Pacific Ocean. Compare areas. Do the same for the part of the United States representing Virginia.

2. Studies of the ocean currents indicate a pattern of water movement which can be charted on maps.

Study maps of the major ocean currents and determine the effect of these currents on nearby land areas. Which major current most affects Virginia?

3. The topography of the ocean floor is similar to that of the lithosphere.

Use reference materials to find information about the topography of the Atlantic Ocean or Pacific Ocean. Construct models of the ocean floor based on data obtained.

4. Tides occur in a regular pattern.

Obtain time charts on the tides and note the regularity with which they occur.

Use reference material to determine the difference of water depth at high and low tide in various parts of the world, such as the Bay of Fundy.

5. Temperature of bodies of water vary with depth, salinity, season, and location.

Research thermoclines and spring and autumn overturns.

Prepare five solutions of salt water with differing concentrations. Place a thermometer in each container. Label each container with the salt concentration. Place the containers in a freezer and check periodically to determine when, or if, each freezes. What relationships were noted?

IV. All phenomena exhibit systematic relationships. Organization is evident in the relative positions and motions of objects in the universe.

A. The celestial bodies in the solar system display an organizational pattern.

1. Earth and other planets move around the sun in the same direction and in approximately the same plane.

Use model of solar system or planetarium to show direction of planetary revolution. (Note that models are not to scale for size or distance.)

2. Clues to the regularity of Earth's revolution and rotation are evident in seasons, day and night,

shadow patterns, and the apparent path of the sun and other celestial bodies.

Take a photograph of a pole, edge of building, or some other fixed object each day or twice a week for a few months. (Include the shadow.) Shoot the photograph from the same spot at the same time on each occasion. Record data about cloud conditions. Arrange the photos in sequence and note any changes in shadow length.

Refer to Time III-C.

3. The revolution of the moon around Earth is observed as orderly phases.

Make periodic observations of the moon during a month. Sketch the shape of the moon at each observation and label with the date, time, and place of the observation. Compare the sketch to the phases shown on a calendar or in the almanac.

B. Matter in the universe tends to be concentrated in specific locations.

1. Man has identified certain star patterns as constellations.

Make models of constellations from clay or plasticine balls. These can be suspended from ceiling using different lengths of string and spacing along ceiling to give three-dimensional effect.

Cut out several squares of cardboard to fit a slide projector. Put patterns of the constellations on the cards by punching holes in them with pins. Project the constellations on a screen and use them for discussion.

Study some of the myths related to the constellations.

2. Man has identified other celestial bodies such as nebula, comets, meteors, planets, natural satellites, and asteroids.

Investigate the location, composition, and other characteristics of these celestial bodies.

3. The Milky Way Galaxy is an organization of related star systems including the Solar System.

4. The Milky Way Galaxy is one of billions of galaxies in the universe.

Show a film.

Visit a planetarium in your school system or one nearby, or on a college campus.

5. Stars show a life cycle from cool to nova or super nova.

Read about the life cycle of stars. Study the relationship of the stage in the life cycle to the color of the star.

6. The sun shows an eleven-year cycle of sunspots.

Study the effects of sunspots on radio and TV transmissions.

C. Matter in the universe is held in its boundaries by forces that display an organizational pattern.

1. Celestial bodies move in relation to other celestial bodies.

2. Orderly position and movement of celestial bodies in the universe can be explained, in part, by interaction of gravity and inertia.

Use appropriate films to develop this concept.

Refer to Interrelationships IV.

V. All phenomena exhibit systematic relationships. Man must learn to live in harmony with the organization of the universe and his activities should enhance, rather than imperil, the organization of natural conditions.

A. Earth's surface is not uniformly endowed with natural resources.

1. Water and minerals, as well as other natural resources, are unequally distributed in relation to land areas, political boundaries, and population.

Study resource maps, physiographic maps, and population maps. Use the most complex map as the base, and make over-lays of the other two maps. Study relationships observed or inferred.

Determine the natural resources which this country must import from other countries. Predict what would happen if these were not available due to political reasons.

2. Raw materials and energy supplies are generally obtained from locations which yield the greatest amounts at the least cost.

Invite representatives from a local industry which utilizes raw materials to explain resource acquisition for the company.

B. Resources may be classified as renewable or non-renewable.

1. Animals and plants are renewable resources.

Design a bulletin board display which differentiates between renewable and non-renewable resources.

Relate the concept of renewable plant and animal resources to the reproductive rate.

2. Soil is classified as a renewable resource; however, due to the time involved in its renewal, soil may be more accurately viewed as a depletable resource.

Invite a soil scientist from the Soil Conservation Office to bring to the class a collection of soil profiles and soil types. Differentiate between major soil types, with particular reference to soil richness due to decaying organic material.

3. Minerals are non-renewable resources.

Study the mineral resources which are in low supply and their predicted period of availability at the present rate of consumption.

4. Water is a reusable resource; however, the available quantity and quality may be affected by man's activities.

Visit a sewage treatment plant and discuss with the supervisor the quality of the discharged water.

Obtain figures on water consumption by typical daily activities such as laundering, bathing, and dish washing. How can individual planning reduce the quantity of water used?

5. Most resources are subject to depletion in terms of quantity, quality, or both.

Study animals which have become extinct or are in danger of extinction and the factors which influenced these events.

C. An effective policy of natural resource management is dependent upon a political system which realistically reappraises policies and programs in relation to their effect upon the public interest and in relation to scientific knowledge about natural resources.

1. Man is developing and applying knowledge to affect population growth, modify environments, and alter the patterns of resource use.

Use current periodicals as sources of information. Compare conflicting reports on the same topic.

2. Various limitations are experienced and certain risks are taken when man attempts a planned program of resource use or environmental management.

Invite resource people to explain the problems involved in environmental management including the attempt to balance the effects of various techniques.

Refer to Change V-B.

SPACE is the unlimited three-dimensional expanse within which all objects exist and all events occur. In some instances, as in a floor or a field, the extent or area of space may be considered only in two dimensions. Space contains all matter, but is not matter itself. Everything made of matter occupies some space, and only one object or piece of matter may occupy a space at any one time.

The term "space" to many people means something beyond Earth, travel by astronauts, or the planets and stars which occupy astronomical space. The concept of space includes more than astronomical space. All living things require a life-space in which to carry on life functions. Some things occupy space and at the same time contain space on the inside such as a cup, bottle, or house.

Children gradually build understanding of space and its vastness through everyday experiences. A young child's perception of space is related almost entirely to self. As a child orients himself to home, school, and community the idea of space develops. Broadening of the concept continues through life as greater awareness of Earth and universe develops.

SPACE

I. All matter exists within space. Living things require a life-space in which they function.

A. The amount of space required by a living thing is dependent upon its size and demand for food, air, and other resources.

Plant four corn seeds each day for four weeks. At the end of this period compare the space occupied by the plants in different stages of development. (Seeds which are soaked in water overnight before planting will germinate more easily.)

Examine the amount of food recommended by dog food processors for dogs of different sizes.

Ask a representative of the Future Farmers organization to visit the class and explain the relationship of field acreage to number of cattle or sheep which can be grazed. Also explore the need for water in this relationship.

B. Living things may react to inadequate space by:

1. migrating to area with greater space

Relate this concept to the westward movement in American history.

Examine various issues of *Virginia Wildlife* to locate articles about animal migration and hunting season kills. Compare statistics over several years if information is available.

2. competing for territory

Read—Steurt, Marjorie. *The Kingdom of Mimus*. Golden Gate Press, San Carlos, California, 1964.

Observe birds on the playground or at home. Notice the territory established. Note competition for food around feeding station.

3. growing to less than potential size

Talk with the proprietor of a pet store about growth of some fish in relation to tank size and population size.

Ask a person who grows plants for a hobby or profession to explain the term "root bound." What happens to root bound plants?

4. reducing reproductive activities

Investigate food crop production levels in a crowded field and compare to a well-spaced field.

Ask the Game Warden to make observations about the number of young produced by various species in relation to population levels.

5. dying.

Read about the "Death March of the Lemmings" which seems to occur in response to overpopulation.

Observe plant succession in a field and the death of some plants as a part of this cycle. Refer to Adaptation V-A and Equilibrium I-A-3.

Investigate stories in reading textbooks, short story collections, and library books which may relate to ideas in this section.

II. All matter exists within space. Space contains all matter, but is not matter itself.

A. Every particle of matter occupies space.

B. No two particles of matter can occupy the same space at the same time.

Fill a glass with water. Gently add several pebbles or marbles. Note the results. Why did the water overflow?

C. Space is the environment through which energy moves.

1. Sound moves on air molecules, or through some other matter.

Strike a tuning fork with a rubber mallet or against a rubber shoe heel. Listen to the sound produced. Strike the tuning fork again and place its handle against a table top. Listen to the sound. Is there any difference in the sounds? Why?

Beat on a toy drum. Feel the vibrations. Put some dry cereal on the drum and strike again. What happens to the cereal?

Investigate the way in which various musical instruments produce their characteristic sounds.

Slap the air with a ruler. Next slap a desk top with the ruler, using the same force. Is there a difference in the level of noise produced? Why?

2. Radiant energy moves through astronomical space.

Study about the length of time needed for light to reach Earth from the sun and other stars.

Read about radio and television communication between moon-roving astronauts and the space agency stations.

D. Atomic particles move through space within the atom.

View atomic drawings and movies which illustrate movement of atomic particles, particularly electrons.

III. All matter exists within space. Earth occupies space and has space within and around it.

A. Space is not empty.

1. Space is occupied by visible and invisible matter.

Fill a bucket or sink about three-fourths full of water. Fill a glass with water and invert it in the bucket or sink. Invert a second glass in the bucket or sink keeping it full of air. Tilt the air-filled glass slightly to slowly release the air and catch the air bubbles in the water-filled glass. Observe results. Repeat the activity using colored water in the glass.

Fill a bucket with large rocks. Is bucket full? Fill the bucket of rocks with sand. Is bucket full? Now fill the bucket with water. Is bucket full? (Large objects take up more space than small objects. Space which is occupied by air can be occupied by something else if the air is displaced. Air occupies space not occupied by some object.)

2. Two objects cannot occupy the same space at the same time.

Play musical chairs. How does this game illustrate this concept?

B. Space on Earth is limited; however, over long periods of time changes have taken place in matter occupying this space.

1. Earth's size or mass has been relatively constant throughout time.

Study various theories as to Earth's origin or formation, and the major changes which have occurred to the present. Do these indicate any change in Earth's mass or the amount of space Earth occupies?

2. Proportion of land to water has changed in response to changing temperature.

Read about the various ice ages and the interglacial periods. Determine what area in this country was covered by the last ice age.

3. Proportion of Earth's space that supports life has changed in response to geological forces.

Relate to ice ages and change in area able to support life.

Conduct research about changing shape of continents through Earth's history, and the Theory of Continental Drift. Also study the changing patterns of vegetation if maps of such are available.

4. Proportion of land area to occupants and objects has changed.

Review population maps to show that growth in population has brought about a need for using land for building purposes, and the changing ratio of land area to number of people per acre or square mile.

Discuss need for establishing open-space area in this country.

Refer to Space V, and Change V-D-2.

IV. All matter exists within space. Space in the universe is vast.

A. Astronomical space includes space in the universe beyond Earth's atmosphere.

1. Astronomical space is not empty.

2. Matter and radiant energy are found in astronomical space.

Identify those conglomerations of matter found in the solar system such as planets and satellites. Read about meteors and other matter in space with less well-defined orbits.

B. Ideas of the vastness of space are relative.

1. Earth occupies a small space as compared to the sun.

Construct a model of the solar system using the following information. For distance use a scale of one inch equals one millions miles.

Mercury	36″ from the sun
Venus	67″ " " "
Earth	93″ " " "
Mars	141″ " " "
Asteroid Belt	300″ " " "
Jupiter	483″ " " "
Saturn	886″ " " "
Uranus	1783″ " " "
Neptune	2791″ " " "
Pluto	3671″ " " "

For sizes of sun and planets use the following:

Sun	a gigantic balloon
Mercury	a small marble
Venus	a tennis ball
Earth	a tennis ball
Mars	a pingpong ball
Jupiter	a basket ball
Saturn	a soccer ball
Uranus	a baseball
Neptune	a baseball
Pluto	a small marble

If balls are not available, students may draw circles on paper with diameters as indicated. Stapled newspaper sheets may be used for the sun. The symbol for each planet, the number of moons it has, its color and any other interesting information can be included in this project.

Sun	5 feet	Jupiter	6¾ inches
Mercury	¼ inch	Saturn	5½ inches
Venus	⅝ inch	Uranus	2¼ inches
Earth	⅝ inch	Neptune	2¼ inches
Mars	⅜ inch	Pluto	¼ inch

2. Man has found it necessary to devise specialized units of measure for the vast distances in the universe.

Become familiar with such terms as scientific notation, Greenwich Mean Time, light year, and other units of measure.

C. Man's use of scientific and technological knowledge has made the exploration of space possible.

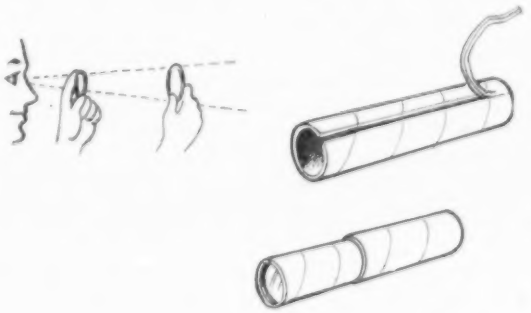
1. Space satellites are used for communication and collection of information.

Use reference material to study the various types of space satellites. Give specific attention to one of particular interest, such as a weather satellite or a television broadcast satellite.

2. Optical and radio telescopes are used to locate distant celestial bodies.

View films about various types of telescopes.

Construct a simple telescope by placing two lenses inside a telescoping mailing tube. Obtain a cardboard mailing tube, tape, piece of corrugated cardboard, two different sized lenses, scissors, small saw or knife, and white paper or cardboard. (The objective lens should have a focal length of about eight inches, and the eyepiece lens a focal length of one inch.) Determine the distance needed between the lenses by holding the eyepiece (smaller) lens close to the eye, and by looking through both the eyepiece lens and the objective lens. Move the objective lens until a clear image is formed of an object in the classroom. Measure the distance between the lenses. The mailing tube must be longer than the measured distance. Cut the mailing tube in half. From one half, cut a quarter inch strip running the entire length. Place edges together and wrap with tape. (This smaller piece should slide easily into the larger piece.) Mount each lens in a ring of corrugated cardboard and tape securely. Tape each lens in the appropriate end of the tube. Look through the eyepiece lens and focus by adjusting the length of the tube. DO NOT LOOK AT THE SUN.



Ask an amateur or professional astronomer to bring a small telescope to show the class.

3. Development of life-support systems has enabled astronauts to survive in space.

List essentials which man must take with him to sustain life in space.
Write stories describing an imaginary space flight.
Study the foods men eat in space.
Conduct research on space suits worn by astronauts and report to class.

4. Specialized equipment is used for rapidly collecting, transmitting, and sorting information.

Discuss the role of the computer in today's world.
View movies about computers.
Visit a business which uses computers.

V. All matter exists within space. Man must learn to live in harmony with the universe and to utilize space advantageously.

A. Earth, with its life-supporting atmosphere, is a closed-space system in relation to resource supply and waste disposal.

1. Utilization of resources and disposal of waste occur within this closed-space system.
2. Recycling may extend availability of resources and salvage materials previously labeled as waste.

Save non-spoilable waste items from the class trash can for several days. Devise various uses for these items. What use could have been made of the spoilable waste items?
Determine the availability of various salvage firms in your area. What types of waste could be recycled? How would such recycling decrease resource depletion?

B. Environmental contamination results from over-use of space.

1. Over-use of space results from increasing human population and rising standards of living.

Locate old photographs of your town or community for varying time periods. What evidence is there of change in population size and density and in the standard of living?
List and describe the change in life style if man reverted to a life style of the "good old days" of 50 to 100 years ago.
Write stories which describe the reactions of a cave man, Columbus, George Washington, or other person of a bygone era if he visited the U. S. A. today.

2. Man may seek unusued space for resources and colonization with increasing resource depletion and environmental contamination.

Form small class committees. Select a relatively unpopulated area in the world to establish a colony. What requirements would be set in terms of food production, housing, water supply, industry, resource use, and other issues for the new community? How dependent would the new community be upon more advanced areas? What adjustments would man have to make in order to survive in this new community? Allow each group to make a visual and/or oral presentation to the class about their new community.

3. Precautions must be taken to avoid contamination and pollution beyond Earth.

Read about precautions taken with early moon exploration teams and rock samples to avoid the possibility of introducing foreign contaminants on Earth. Why must the reverse procedure be undertaken?

C. Space must be used with the greatest efficiency and the least drain on resources.

1. Multiple-land use should be planned as population increases and available land becomes limited.

Study a community map to locate areas of multiple-land use such as shared parking facilities, playground areas, and multiple building use by groups such as schools and community groups. What additional multiple-use categories might be initiated? How can this be related to zoning regulations?

2. Habitat management for wildlife can serve to control their population.

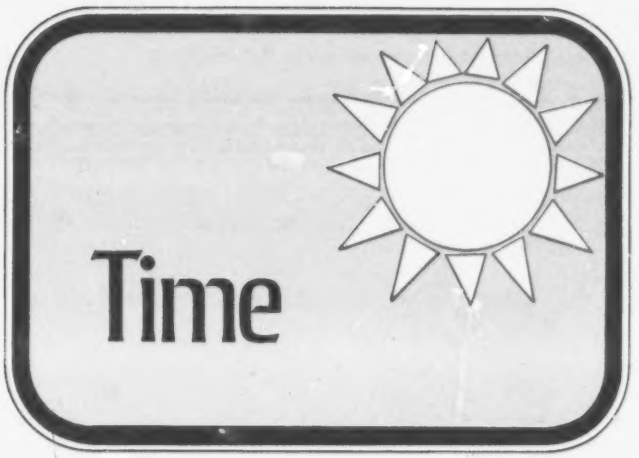
Consult the game warden for your area about wildlife management procedures employed locally.

3. Zoning of land areas establishes land-use categories based on the needs of localities.

Study the zoning requirements and zoning maps for your community. Discuss these with an elected or appointed official.

4. Architecture can make possible more effective and aesthetic use of space.

Gather pictures of buildings, interiors, rooms, parks, and other areas which are attractive. Suggest ways unattractive buildings might be improved. Build models to illustrate the ideas.



TIME may be described as a non-spatial continuum within which something exists or occurs. This dimension of the universe answers the questions when, or how long. Interval (how long) refers to the duration in time, while epoch (when) means location in time. Both are expressed in the same units—second, minute, hour, day, and so on. Time expressed as an interval might be: Lunch period is 30 minutes long. Time expressed as an epoch might be: Lunch begins at 12 noon.

Man has devised a variety of systems and methods by which time may be measured. These measurements are made in relation to space or by something moving through space such as flowing sand grains, turning clock hands, or revolving planets. From a given point in time, measurements may be made in either direction—before or after. Time has no breaking point and, therefore, is continuous. One cannot relive the past, and in this respect time is continuous in one direction only.

Time is an abstract concept, and development of real understanding is a slow process. Elementary school children become acquainted with time in relation to their immediate experiences. As their concept of time expands, children begin to understand time in relation to other things: the time needed for eggs to hatch, or the time dinosaurs lived, or the time for summer vacation.

I. All phenomena have relationships to time. Living things are affected by the passing of time.

A. A living thing exists within a period of time called a life span.

1. Average life spans are characteristic of a species.

Write Commission of Game and Inland Fisheries for information about the life spans of wild animals in Virginia. (Box 1104, Richmond, Virginia 23230.)

Make a graph with life spans on one axis and species on the other. Does size of animal influence life span? Does environment influence life span? Describe any other interesting facts the graph reveals.

2. The length of the average life span may change over an extended period of time.

Use reference materials to locate the life span of several different species of animals in their natural habitat and in zoos. Compare results.

Consult county agents and others to compare the productive life of various food plants, the extended growing period, and resistance to disease.

Invite a life insurance agent to visit the class to discuss facts about the increase in man's life expectancy. What has contributed to the increase?

3. Aging of organisms is relative to their own life spans.

Fill in charts for a number of animals and plants. Study the chart and look for any interesting patterns that appear in the time for various stages in the life span.

ANIMALS	From fertilization to hatching or birth	To reach maximum growth	To reach reproductive maturity	Period of reproduction	Declining years	Total life span

PLANTS	For germination of seeds	To produce first blossoms and fruit	Of period of reproduction	Total life span

B. Certain functions of living things seem to occur at specific time intervals.

1. The occurrence of some life functions, though powered internally, appear to be timed to and controlled by external changes on Earth such as seasons, daylight/darkness, and tides.

2. These internal biological clocks seem to control activities such as migration, reproductive cycles, opening and closing of flowers, and feeding times.

Prepare bulletin board display to show time of year that the young of animals appear, when seeds of plants may be gathered, and the time of feeding and resting of insects, birds, and other animals.

Prepare a map to show migratory pathways for birds and dates of migration for various species.

Make a graph to record the time of feeding of certain wild and domesticated animals. Relate time of feeding to type of food consumed.

Observe life on the beach at low and high tides. Read about the life cycles of sea turtles, crabs, and other aquatic life.

Observe and record the times of opening and closing of certain flowers such as:

Four O'clock	Hawkbit
Chickory	Water Lilies
Portulaca	Poppies
Star of Bethlehem	Tulips

C. Earth existed a long time before animals and plants existed.

1. Some creatures that lived on Earth are now extinct.

Make clay or paper maché models of animals and plants to be used in dioramas of different eras of Earth's history. Describe why some of these organisms are now extinct.

Take a field trip to a quarry or area of sedimentary rock to find fossils of plants and animals. Talk with knowledgeable persons, curators of museums, geologists, or paleontologists about your findings.

2. Variations of existing creatures are evolving as a result of interrelationships with the environment.

Make reports on the work of artificial cross pollination and grafting of plants, and cross breeding of horses, dogs, and other animals.

Study references to ascertain how creatures are changing as a result of interrelationships with the environment. Refer to Change I-B and Organization I-B-4.

II. All phenomena have relationships to time. Matter and energy exist in time.

A. The sum of matter and energy in the universe is constant throughout time.

Write an imaginary story using as the main character an atom of an element, possibly a carbon atom, an oxygen atom, or some other element. Trace its journey through time. (Bring out idea of time needed to change form, and that the sum of matter and energy is constant.)

B. Time is a factor in transformations of matter to energy and energy to matter.

1. Growth of living things involves an exchange of energy.

Grow some plants from seeds. Observe growth and chart progress of plants over a period of weeks and months. Relate the energy produced by the sun to the process of photosynthesis and to the accumulation of matter as the plant grows.

2. The rate at which physical and chemical changes occur is affected by a variety of factors including the stability and temperature (heat content) of the materials.

Obtain equal amounts of cold water and hot water in beakers or jars. Add equal amounts of sugar to each container of water. Observe results. In which does the sugar dissolve first? Why?

Consult reference materials to determine the stability or reactivity of lithium, phosphorous, and sodium. (Sodium and lithium in pure form are stored in kerosene, and phosphorous is stored in water to prevent reaction with elements in the air.)

III. All phenomena have relationships to time. Changes on Earth and of Earth's position are used to measure time.

A. Man's conventional units of time are inadequate for locating occurrences in the geological past.

1. Earth's history has been divided by man into eras, periods, and epochs.

Study the geological time scale to grasp the idea of the past history of Earth. Emphasize the varying climatic conditions, life forms present, and changes from era to era. (Awareness of the various periods represented is the only requirement for the elementary child. *Do not* attempt any memorization of names or dates.)

2. These divisions of time on the geological time scale are of unequal duration.

Compare the various times man has designated as eras, periods, or epochs in the geological time scale. (Note that the geological time scale is based on changes identifiable as distinct differences in Earth's physical environment and changes in living things.)

Study the geological past with a view to understanding the development of Earth and life on it. Understand that man has assigned periods of time to this development for identification purposes.

B. Man's ideas of the relative age of Earth were derived through study of Earth's crust.

1. The present rate of deposit of sediment may be compared with the entire thickness of sedimentary rock as a method of estimating the age of Earth.

Place equal samples of different types of soil in separate jars of water. Stir. Graph the time it takes for the soil samples to settle out.

Visit a stream to find places where soil has settled out of the water.

View films of canyons that show layers of rock. Study how these layers may be used to approximate the age of Earth's crust.

Invite a highway engineer to explain what is learned from core samples.

Use reference material, such as geological maps, to locate large delta areas throughout the world.

2. Fossils found in sedimentary rock provide information about the age of Earth.

Make a display of fossils that people in the community may have acquired, or borrow such a display from the museum.

Visit an excavation site or a geological dig to hunt for fossils.

Read about fossils to find out what methods man has devised for determining the age of fossils.

3. The most accurate method man has discovered for estimating the age of Earth is based on radioactive decay which takes place at a fixed rate for specific elements.

Go into a completely darkened room or closet and wait for eyes to become adjusted. Examine a luminous dial of a clock or watch. Use a magnifying glass to reexamine the watch face. See the tiny bursts of light being given off.

Bring a Geiger counter into the class. Bring the probe near a clock or watch with a luminous dial. Examine what happens if it is brought near some rocks. Read about this instrument.

Read about radioactivity as used to determine the age of rocks and of Earth.

C. Time on Earth is reckoned by movement of Earth in relation to other celestial bodies.

Draw a circle on the playground or blacktop area. Place a stick or a yardstick in the center in an upright position. Observe the shadow of the stick and the general position of the sun in the sky at different times of the day. *DO NOT LET CHILDREN LOOK DIRECTLY AT THE SUN.* Mark position of shadows. Repeat daily. Read reference materials to find the reason for changes in the hours of daylight.

List the units of measure for time that man uses and the numerical relationships.

IV. All phenomena have relationships to time. All measures of time depend upon observing and recording some regular occurrence in the universe.

A. Observation of relative motion of celestial bodies has led man to devise units for measuring time.

1. Rotation of Earth on its axis in relation to the sun causes day and night. Man has subdivided one rotation into fractional parts called hours, minutes, and seconds.

Suspend a weighted wire from the ceiling. (The device used to attach the wire must be low in friction production to allow 30 to 60 minutes of uninterrupted swinging.) Tie one end of a three-foot string to the weight, pull it to one side and tie it to a chair. When the weight is motionless, cut or burn the string, then mark the path of the swinging pendulum every five or ten minutes, using a tape. (It will seem that the path rotates. The pendulum is swinging in the same plane; however, Earth is rotating under it. A significant movement of Earth will be indicated by the pendulum after 30 to 60 minutes, since Earth rotates 15° per hour.)

2. The moon revolves around the Earth in approximately a month.

Record the position of the moon from a specific location on the playground during the part of the month when the moon is visible during daylight. Observe at the same hour each day until the moon again appears in same position. How long did it take to reappear? Will it happen again in the same length of time?

Consult reference materials to see why we see only one side of the moon.

Find folk tales about activities in which people engage at different phases of the moon, and the different names the moon has during various times of the year. Consult an almanac and other reference materials for ideas. What evidence can be gathered to show that many folk tales have basis in good observation of natural phenomena and are not entirely superstition?

3. The period of revolution of Earth around the sun is called a year.

Use references to find how man has determined the length of a year and devised a calendar. Why has man changed the calendar?

Observe change of seasons during the year. How many changes or seasons?

Collect stories or poems about the year and the seasons. Write stories about the seasonal changes during the year.

4. The pattern of changes in the lengths of day and night is the basis for dividing the year into seasons.

Prepare a display about seasons. Using four different colors, lightly color the portions of a calendar during which the four seasons occur.

Keep a record of the time the sun rises and sets each day. Gather information from an almanac, newspaper, radio broadcast, or television program. Why are the hours of sunlight fewer each day in autumn in North America? Why do the hours of sunlight increase each day during spring?

Discuss the causes of the changing length of day and night.

B. Man recognized the lack of uniformity in the Earth's motion in relation to the sun.

1. Apparent solar time varies for different locations on Earth.

Read stories that tell about length of daylight at the poles, the equator, and other geographical areas of the world.

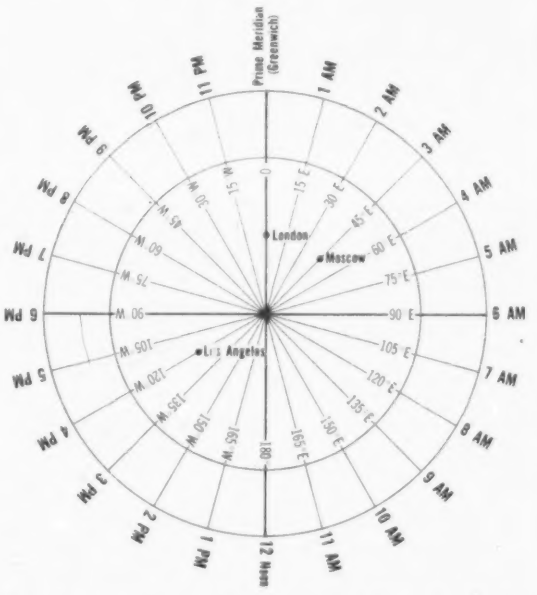
Prepare a chart to show differences in lengths of daylight in summer and winter for different parts of the world.

a. Man uses the mean or average solar time for regulating his daily activities.

Using chart developed under Time IV-B-1, find the average length of time the sun is visible; not visible.

b. Man has organized Earth into standard time zones based on scientific data, and adjusted to suit the convenience of the majority of the population.

Draw a circle having a six-inch diameter and another with an eight-inch diameter. Use a protractor and mark each circle with areas 15° apart. Number the lines on the eight-inch diameter with A.M. and P.M. hours. See diagram.



Put the six-inch circle on the eight-inch circle. Fasten them together at center with a paper fastener. On the six-inch circle, print the names of cities at their correct longitude. Include Greenwich, England. When you line up the name of a city with a time you will be able to read what time it is at that moment in every city on your dial.

Discuss time zones. How many time zones are crossed in traveling between two selected cities going East to West? West to East?

Use a time zone map of continental U. S. to locate the four time zones. Establish the fact that this same idea is used throughout the world using the Prime Meridian as the starting point and advancing time moving east and setting time back moving west one hour for every 15 degrees of longitude. Notice adjustments of time zones around areas of concentrated population. What is Daylight Saving Time?

C. In measuring the passage of time, man has invented a variety of devices for counting time units.

1. Early methods for counting time units include measurement of shadows, flow of water or sand, and burning candles.

Observe the movement of shadows cast by the sun. Inscribe a circle on the playground. Place a stake at the center. Mark the positions of the shadow of the stake at specified times during the day. Record results. Repeat about a month later with stake in original position. Are there any differences? Why? Use references from the library to answer questions.

Use library resources to find how man used water to measure the passing of time. Construct a water clock.

Bring two identical candles to school. Place them in holders out of any draft. Light one. At the end of an hour extinguish the candle and mark the fresh candle to show how much of the other candle burned in an hour. Mark both candles to show successive hours. Repeat above to test your finding. Why is this type of clock not in use today?

Use reference material to find out what is known about the arrangement of stones at Stonehenge in England.

2. Regular motions of mechanical parts or of molecules are a basis for the operation of clocks today.

Invite a jeweler to visit the class to explain how a clock works and the types of clocks in use today.

Use simple diagrams, charts, filmstrips, and other media to explain the mechanical operation of several different types of clocks.

D. Space and time measurements are interdependent.

V. All phenomena have relationships to time. Man must learn to live in harmony with the universe, and his activities should enhance, rather than imperil, natural conditions throughout time.

A. Doubling of population in increasingly shorter periods of time causes a markedly increased rate of resource depletion.

1. With increasing population, and the resulting demands for water, priorities may have to be established for water-use.

Cut a sponge into eight strips. Fill three glasses with equal amounts of water. Insert one strip in first glass, two strips in second glass, and remaining strips in third glass. After strips have become saturated, remove them carefully and note the amounts of water remaining. Discuss results in terms of sponge strips representing population and the demands for water.

Gather information about amounts of water used daily by an individual and a family of four. Compute the amount of water needed annually by your city or community. Discuss essential and non-essential uses of water. List regulations that might need to be established to guarantee enough water.

2. With increasing population and decreasing supplies of resources, individual use of resources may be subjected to certain regulations in relation to the overall needs of society.

Refer to Organization V-B.

Make a chart showing populations of some major countries and the production of rice, wheat, corn, or other staple crops:

Country	Population 1920	Wheat 1920	Population 1970	Wheat 1970	Estimated Population-1980	Estimated Wheat-1980

List regulations which may be necessary for adequate food supplies for the world population of 1980 and beyond.

3. If over-population is to be avoided, and a reasonable standard of living is to be assured for future generations, the present generation must take steps to slow population increases.

Refer to Change V-D and Variety V-A-5.

B. Through time, cultures with higher levels of technological development have used more natural resources than those with lower levels of technological development.

1. A cultural and time lag is evident between development of scientific and technological knowledge and its application in improvement of human life and the environment.

Discuss reasons why many people do not fly although scientific and technological knowledge have made it possible to cross the U.S.A. in five-and one-half hours. Discuss advantages people might enjoy if they used this convenient method of travel and traveled more frequently. Collect travel and tour brochures, noting advantages listed for flying to various destinations.

Interview a farmer to determine modern means of harvesting a crop. Discuss reasons why many farmers do not use the new devices for harvesting their crops. Point out advantages if they did use such equipment.

2. Increased leisure time, higher income, improved road and transportation facilities, and interest in the out-of-doors have strained existing recreational areas and created the need for new ones.

Study maps to determine the availability of recreational areas. Obtain statistics and news items that show use of recreational areas. Discuss most popular activities pursued in each area, possible overcrowding, and the need for additional facilities within an area.

3. Increased money available for non-essential items, and the ability of American industry to produce and advertise various products has increased use of resources.

Conduct a survey of parents to determine what non-essential items are enjoyed today that might not have been used or bought by the family ten years ago. Determine the reasons why families are able to enjoy such items today. Determine what resources are used in production of these items.

4. The economy of a region is dependent upon using its natural, human, and cultural resources and effective technology over a period of time.

Make a product map of Virginia. Show where peanuts, tobacco, and other crops are grown, where slate is mined, and where timber is harvested. Make a map of industries of the State. Compare the maps and write articles giving reasons why these industries have developed. Indicate the dependence of industry upon natural resources.

Make a map showing location of museums, art galleries, theaters, and other cultural centers and institutions of higher learning. Discuss contributions of such centers toward the economy and culture of the State.

C. Long-range planning for allocating and using human and natural resources should be a continuous process.

1. During our lifetime we have legal ownership of some resources and control over others through individual and political action; however, decisions concerning use of resources must be made with consideration for effects upon future generations.

Refer to Variety V-B.

Discuss laws involving use of resources when ownership is private, city, county, state, or federal. Apply this to use of school facilities and the need to share wisely for benefit of all.

2. The rate of resource depletion can be slowed by the development and implementation of alternatives.

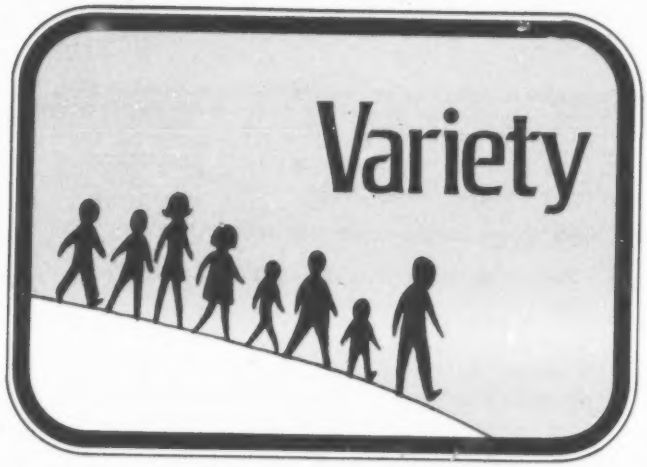
Refer to Space V-A, Organization V-B and Change V-D.

3. Because of resource depletion choices must be made between those things which are essential and those which are desirable but non-essential.

Divide the class into small groups and list the items which are essential for life and those which are luxuries. Relate the luxuries to resource depletion. What effect does packaging of an essential, such as food, have on resources?

4. Short-term economic gains may be selected at the expense of long-term environmental benefits.

Discuss allowances which children receive. How many children save a portion for a specific item they might want? What are the advantages of such saving? What must be sacrificed in order to save for something else?



VARIETY in many dimensions may be observed in the universe. In the solar system planets exhibit variety in characteristics such as the presence or absence of moons and the period of rotation and revolution. On Earth an observer simply needs to use his senses to perceive variety on display in the forms and types of plants and animals, rocks and soil, textures, colors that are ever-changing in the light from the sun, odors, motions of living things, and sounds produced by natural and man-made phenomena.

Variety in the characteristics of the elements and the variety of combinations of these elements which exist produce a vast array of compounds. The variety in these compounds means the difference between a piece of limestone and a diamond, between a mouse and a rose, and between a helpful medication and a poison.

Among people variety is evident to the degree that no two individuals are identical. Even though differences of language, customs, life style, and religions add to the variety, many basic similarities and needs exist among the peoples of Earth.

Variety makes living more interesting by its presence. Without variety man would very likely become bored with the routine sameness of his surroundings.

VARIETY

I. Similarities and differences exist in all phenomena. Variety exists in living things.

A. Living things exhibit variety in body structure.

1. Body sizes range from unicellular to multicellular.

Walk around the school to note differences in size, shape, and complexity of plants and animals.

Visit a farm, zoo, or pet shop to observe differences in size and shape of animals.

Take a field trip to a nearby pond or small lake to observe the many small animals which live there.

Use a microscope to observe lifeforms in a drop of water from puddle, pond, or river.

2. Shapes of the whole body or of the various parts are diverse.

Conduct field trips around the playground and area surrounding the school to find and observe variations in structure of the same or very similar plants.

Examine flowers from several different plants and see if you can find certain features the flowers have in common. Research books to identify these features and the functions they perform.

Discover the differences and similarities in the structure of vines, shrubs, and trees.

Secure charts showing the great variation of animals, particularly dogs and cats, or have a veterinarian visit the class with the charts.

Form class committees to study parts of animals: feet, wings, mouth parts, eyes, and other features. See Adaptation I.

Develop a chart showing the great variety of animal life. Consult a variety of reference materials and list or illustrate examples ranging from the smallest to the largest animals.

Request that the police department send the police artist to your school to show the kit used to make composite drawings of people. (The kit contains examples of different shapes of eyes, noses, mouths, and other facial features.) Have the artist prepare a composite drawing of a member of the class based on the description given by other class members. Can the person be identified from the drawing?

3. Many colors are evident in plants and animals.

Take a field trip to observe colors of plants and animals. List colors seen. Which colors are most abundant? Why? (Note the scarcity of blue.)

Use colored pictures, films, and filmstrips to study the protective coloration of various animals.

Discuss how coloration can aid various animals in the procurement of food.

Develop posters and charts to show the variety of colors of animals living in different habitats. Refer to Adaptation III-C-1.

Contrast colors displayed by male and female of the same species.

4. Complexity of body structure is different among various plants and animals.

Make collections of leaves and seeds of plants to show variety of texture, color, shape, and complexity.

Draw or collect pictures for posters to show variety of appendages in animals. Refer to Adaptation I-A-1.

B. Living things exhibit variety in function.

1. Basic life processes are performed by all living things, but variety is evident in the method of:

a. obtaining oxygen

Observe the method of breathing of land animals and water animals.

b. obtaining food

Report to the class on the food supply of various domestic and wild animals.

Observe birds and insects on the playground, and list various methods of food gathering by these organisms.

Use a magnifying glass to observe caterpillar mouth parts as leaves on plants are consumed.

Observe motions of tongue of cats and dogs as they feed.

Refer to Adaptation I-A-2.

c. moving

Observe movement of tadpoles in an aquarium. As the adult stage of the frog develops another method of movement can be observed.

Make a chart listing methods of locomotion of animals in a variety of habitats such as:

HABITAT	PART OF BODY	ANIMALS
Aquatic	Cilia	paramecium
Aquatic	Fins, flippers & tails, claws	fish, crab, etc.
Land	Two feet	birds, man
	Four feet	horse, dog
Air	One pair wings	birds
	Two pairs of wings	insects

d. excreting wastes

Observe animals on farm, in aquarium, in cages at a zoo or classroom. Observe evidence of animal wastes in woods and fields.

e. reproducing

Use a microscope to observe reproduction in one-celled animals.

Take a trip to a fish hatchery. Observe the parts of a fish's life cycle.

Take a field trip and observe that some plants start from the root system of a parent plant.

Take a field trip in spring to note different kinds of flowers (staminate and pistillate) on same tree and on different trees of the same species.

f. responding to stimuli.

Refer to Adaptation I-A-3, A-6, B-1, II-A; Change A-2; Equilibrium I-D; Interrelationships I-B; and Oragnization I-A-1.

Place a bag over part of the leaf system of a plant. Place the plant in sunlight. After several days, uncover the plant and observe changes.

Observe the leaf arrangement of potted plants placed in the window. Change the position of the plants several days and observe results.

Obtain two sheets of glass about 6″ x 6″, a piece of paper towel, pie pan, rubber bands, some clay, and some bean seeds. Place a wadded-up piece of paper towel on one sheet of glass. Place several seeds on the towel and cover with the second piece of glass. Fasten the sheets of glass together with the rubber bands. Prop upright by placing on edge in lumps of clay in the pie pan of water allowing part of the towel to touch the water. Observe the seeds germinating, then turn the glass sheets 180°. After several days note response of leaves and roots. (Seeds soaked in water several hours will germinate more rapidly.)

2. Differences in function are related to differences in structure. Some living things have specialized body parts which perform special functions.

Develop a chart showing foot structure of different birds which allows them to perch on twigs and sides of trees, to swim, to tear flesh, to dig in the soil, and to weave nests.

Observe some animals (wasps, bees, spiders, and birds) and note structures of body used to perform building of nests.

Compare the cell parts of simple animals, such as ameba or paramecium, to the complex organ systems of higher animals.

3. Life cycles of living things are diverse, and are characteristic of an organism.

Obtain eggs of silkworms from a biological supply company. Observe the life cycle of the silk moth.

Study the life cycles of grasshopper, monarch butterfly, frog, and rabbit. Prepare bulletin board display of the life cycles and note similarities and differences.

Plant, tend, and observe life cycle of plants such as marigold, grass, and buckwheat.

4. Variety has resulted from adaptation of living things to the environment.

a. Many prehistoric life forms were different from life forms today.

Visit a museum to study remains of early animal and plant life.

Compare ancestors of the horse with horses of today.

Prepare a chart or make a series of models to show differences between early life forms and those of today.

b. Interaction of living things with their environment is a continuous process resulting in greater diversity.

Make a collection of interesting facts to show the variety of living things. (More than 700,000 different insects have been identified and many more have not been described.) Arrange the facts on a bulletin board display.

List as many fur-bearing animals as you can.

Stake out a one-meter square of soil. List everything found within the square area on at least two occasions three months apart.

c. No two living things are exactly alike in that each occupies its own unique life-space. Because no two living things can occupy the same space, and are made of different cells, no two living things are exactly alike.

Grow plants from seeds assumed to be alike. Place in individual pots and in a favorable environment. Observe for several weeks. Measure growth periodically and graph results. List as many factors as possible which would prevent the plants from being "exactly" alike. How would this idea relate to the uniqueness of individual humans?

d. Man purposely influences variation in living things by cross-breeding and cross-pollination.

Bring in seed catalogues for flowers and vegetables. Study the variety of plants available and the habitats in which they grow best. Make posters showing the different varieties of a flower or vegetable.

Visit a florist, greenhouse, or nursery to find out how and why man purposely changes, or tries to change, plants and animals.

Visit an experimental farm and have the horticulturist show and explain how cross-pollination and grafting are used to produce tastier, larger, and hardier fruits.

Consult the yearbooks of the U. S. Department of Agriculture for articles on hybrid corn. (Seed companies also produce literature on hybrid corn and how it is grown. Your county agricultural agent will give you a list of the names and addresses of such companies.)

Consult reference books to learn about the development of "seedless" fruits. Discuss the advantages of such fruits over "natural" fruits.

II. Similarities and differences exist in natural phenomena. Variety exists in matter and energy.

A. Matter is composed of a variety of elements.

1. The variety in atoms accounts for the variety of elements in the universe.

Show an appropriate film. Consult other reference materials and construct models of various atoms.

2. Atoms and molecules combine in a variety of patterns.

a. A compound is two or more elements which are united to form a substance having special properties.

Pour some lime water into a test tube. Hold thumb over mouth of test tube and shake thoroughly. Observe results. Blow gently through a straw into the lime water for a few minutes. Observe results. What differences were observed in the two instances? What differences exist between the air in the test tube and the exhaled air? What new compound was formed? How is the compound (calcium carbonate) different than the composing elements?

b. A mixture is the result of the physical mixing of two or more substances which do not combine chemically. A mixture can be physically separated into the substances of which it is composed.

Fill a jar with marbles. Add as much sand as possible. Use a piece of screen to separate. Try this with other substances such as sand, sugar, iron filings, bits of cork, and small marbles. Suggest various ways to separate this mixture.

B. A variety of energy transformations are observable.

1. Heat energy can be transformed into light energy.

Strike a match and light a candle. Observe that both the burning match and candle give off heat and light. What other examples can be listed?

2. Chemical energy can be changed into heat energy and/or light energy.

Mix plaster-of-paris and water. Wrap a thermometer in foil and insert in plaster. Record temperature as plaster is setting. Was heat produced in the chemical reaction between the plaster-of-paris and water?

3. Electrical energy may be changed into heat energy and light energy.

Make a bulletin board display of electrical appliances which emit heat and light.

4. Nuclear energy may be transformed into light energy.

Use a magnifying glass to examine the luminous dial of a watch in a dark closet. Record observations. Use books and other resource materials to locate information about nuclear energy and man's use of it.

5. Energy of sunlight is believed to come from nuclear energy.

Show a film depicting the nuclear reaction which produces the energy of the sun.

6. Mechanical energy may produce light energy.

Visit an electric power generating station.

7. Mechanical energy may produce motion in the form of waves through gases, liquids, and solids.

Fill a tub with water. Drop several sizes of pebbles into the water, one at a time. Observe results and discuss varying wave sizes in relation to pebble size.

8. Sounds are produced by a variety of sources. Sound is an example of wave energy.

Ask the music teacher to demonstrate various kinds of stringed and wind instruments. Talk about the various causes of the sounds.

Tap a tuning fork with a rubber mallet or on the rubber heel of a shoe. Place its handle against the top of the table. Place the vibrating fork in a bucket of water.

Remain silent in the classroom for one minute. Observe and record the variety of sounds during that period. Infer the energy source involved. Repeat the activity outside. Compare results.

C. Matter has a variety of properties.

1. Matter may exist as a solid, liquid, or gas.

Make a chart for classroom display listing as many kinds of matter as possible under the headings: Solid, Liquid, and Gas. Which kinds of matter exist naturally in more than one state?

2. Matter may exhibit a variety of other properties such as color, weight, odor, texture, boiling point, freezing point, and density.

Make a collection of objects. Describe an object to a classmate and see if he can guess which object is being described.

Classify a collection of objects by characteristics such as color, size, shape, odor, texture, or weight. (Relate to process skill level of children.)

D. Simple machines use energy to make work easier.

1. Lever type machines are based on motion about a fixed point. Examples are the lever, pulley, and wheel and axle.

Construct working models of the lever, pulley, and wheel and axle. Note the ease of motion involved in these types of machines. Identify the application of these in common household items, toys, and complex machines.

2. Inclined planes are based on the rigidity of the triangle. Examples are inclined plane, wedge, and screw.

Cut three strips of cardboard or tagboard 6" x 1" and punch a hole in each end of the strips. Fasten the three strips together to form a triangle by inserting brads through the punched holes. Construct a square or rectangle using four strips. Compare the stability or rigidity of these two forms. Can the square or rectangle be made more stable by adding a diagonal strip and fastening? Why?

Cut an inclined plane from a sheet of paper. Wrap the paper around a pencil. Does the resulting pattern resemble the grooves on a screw?

III. Similarities and differences exist in all phenomena. Variety exists on Earth.

A. Atmospheric and climatic conditions vary on Earth.

1. Various climates have influenced the distribution of living things.

Consult a world atlas. Study maps showing types of world climates and vegetation. Gather information from reference material concerning crops of certain counties. Infer reasons for various crops being grown in certain locations.

Use reference materials and consult zoo keepers or other knowledgeable persons to find out about animals from different climatic areas. Could these animals survive in a different habitat? Why or why not?

Watch TV programs about animals in other climatic areas. (Select a child to list on the chalkboard the weekly TV schedule of interesting and appropriate programs.)

2. Variations in climatic conditions influence the way organisms live.

Use a globe or map of the world to locate places having great variations in climatic conditions. List plant and animal life in these areas. Determine how organisms are adapted to climatic conditions.

3. A variety of factors influence climate.

Refer to *Using Maps and Globes*, Elementary Education Service, State Department of Education, Richmond, 1969.

Refer to Interrelationships III-B and Organization III-C-4-c.

Mark on a globe or map various places which have the same mean low and high temperatures. Relate location of these places to latitude, altitude, ocean currents, and other factors which influence climate.

4. Within a climatic area there may be daily variations in weather.

Use a calendar to record daily weather conditions. At the end of each month write a summary of the weather conditions to show a sample of the climatic conditions for an area of the state.

5. Weather is a result of a variety of factors within the atmosphere.

Clip weather maps from the newspaper. Write for daily weather maps from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. These are available on an annual subscription or individual basis.

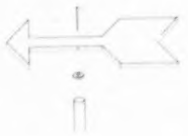
Visit local weather stations to learn about weather recordings and reports.

Establish a weather station for the school. Take daily readings from thermometer and barometer. Record precipitation, wind direction, and velocity. Make graphs to show changes, using data gathered by weather station.

Make simple weather instruments to use in weather station.

Wind vane

Cut an arrow such as this from a piece of wood. Find the balance point between point and tail. Drill a small hole.



Insert a large nail and attach to post.

Place a washer between the vane and its support to reduce friction on the post. Use a compass to determine directions and indicate major compass points on the post.

Barometer

Obtain a jar with medium to narrow mouth. Cut off the end of a rubber balloon and stretch tightly over the mouth of jar. Flatten ends of drinking straw. Cut one end to a sharp point. Glue opposite end to middle of rubber covering the mouth of the jar. Rest straw on a match at the edge of the jar. Place a scale beside point of straw and note rise and fall as air pressure causes straw to move. Will temperature change affect this barometer? (This may require several attempts for desired results.)

Hygrometer

Fasten two thermometers that are alike to a piece of heavy cardboard. Wrap the bulb of one thermometer in a piece of terry cloth. Moisten the terry cloth. Attach a string to the cardboard and whirl the device through the air. Record readings from the two thermometers. Determine

the difference in temperatures of the two thermometers. Consult a relative humidity table using the dry bulb temperature and the difference in the two temperatures to find relative humidity in percentages.

B. Variety exists within the hydrosphere and lithosphere of Earth.

1. The hydrosphere exhibits a variety of characteristics such as area, depth, location, temperature, and mineral content.

Invite a technician from health or water department to explain what is in water and how water is tested for drinking purposes. Ask about the differences between fresh and salt water. How can water quality be improved?

Draw a grid on flat map of the world and talk about the areas of land and water. Use reference material to find out where most of the water is located.

Record temperature using Centigrade and Fahrenheit thermometers at different depths of the water in puddles, springs, ponds, streams, and any natural or man-made bodies of water. Record the findings in the form of graphs. Is the temperature affected by depth? Time of year? Cloudy day? Time of day?

2. The hydrosphere exhibits a variety of characteristic movements such as ocean currents, swift-flowing mountain streams, slower moving lakes or ponds, and seeping bogs and swamps.

Take field trips to a stream or river to observe the direction of water flow. Use a stop watch to time the journey of a twig downstream for a certain distance. Repeat after a heavy rainstorm.

Use films which show water in motion and the water cycle.

Use reference materials to locate ocean currents. Mark them on a map of Earth. Describe the direction of motion and relate to the climate of adjacent land areas. See Variety III-A-3.

Clip the tide tables from a newspaper. Compare over a period of a month to discover the pattern. If living in the Tidewater area, mark the high water line on the shore each day at the same hour. If living in the interior near a lake or stream, mark the high water line and check to see if there is a difference each day for a month. Read reference materials about tides. What different causes for high water levels can be inferred?

List and make a pictorial display of ways man has made use of waterways for commercial and recreational purposes.

3. The topography of Earth has many variations.

Prepare a bulletin board using pictures which depict many different land forms, such as mountains, hills, valleys, cliffs, canyons, plains, and caves. List as many terms as possible used in describing topography of Earth.

Use a sandtable to build a model showing many different features of land formations. Select a specific geographic area, and prepare a model of the area to scale.

4. Many kinds of rocks, minerals, and soils are found in the lithosphere.

Collect rocks and note their similarities and differences. How does man use rock? What kinds are used in specific industries, road building, office buildings, dams, and other structures? What kinds in the collected samples are used in various ways?

Invite the county agent, museum director, or a geologist to visit the class to talk about mineral content and soils found nearby.

IV. Similarities and differences exist in all phenomena. Variety exists throughout the universe.

A. Celestial bodies and systems vary within the universe.

1. Galaxies exhibit variety in form, composition, and organization.
2. Celestial bodies and systems move in various patterns.
3. Celestial bodies vary in distance from Earth.

Use films, filmstrips, and reference materials to introduce the ideas man has developed about the variety of objects of the universe.

Invite a local astronomer to visit the class to explain the operation of telescopes and some things man has discovered through their use.

Visit a planetarium to find answers to questions concerning motion of bodies in space, sizes, distances, colors, and relationships of galaxies. Use the information gained to create a display of pictures, graphs, articles, and models.

2

B. Planets in our solar system exhibit variety.

1. Planets vary in size.
2. Planets have different periods of rotation and revolution.
3. Some planets have one or more natural satellites.
4. The orbit of each planet is at a different distance from the sun.

Refer to Space IV-B.

Make charts showing the classification of planets by criteria such as the order of the planets:

- from the sun
- by size
- by number of satellites
- by distance from Earth
- by the period of revolution
- by the period of rotation
- by ratio of gravity to that of Earth
- by other interesting features.

Make up games such as an Olympic Meet on the moon. If a person can pole vault 17 feet on Earth, how high could he pole vault at the Moon Olympics where gravity is one-sixth that of Earth? (This activity assumes that the need for life-support systems would be taken care of by means of an enclosed Olympic Stadium.) What other events could be included? What would the records be?

Show films and discuss the effects of moon's gravity on the astronauts and the moon rover. What was observed that was evidence of moon's reduced gravity?

C. Stars exhibit a variety of characteristics such as color, size, age, and distance from Earth.

Read stories from various cultures (Greek, Chinese, Japanese, and American Indians) about legends and myths of constellations or stars.

Make up a story to explain some feature that is visible in the night sky.

Prepare a bulletin board to illustrate the varied characteristics of stars such as: size, temperature, brightness, composition, age, color, and position in relation to other stars.

Make shadow boxes of various constellations to illustrate stories and learn about individual stars.

Cut off one end of a shoe box. Punch holes in black construction paper in the shape of the constellation. Paste the paper over open end of box with the proper shape of the constellation to the inside. Replace lid. Cut a one inch hole in center of opposite end of shoe box. Hold the end with the constellation near a light. Look through hole in the other end of the box. What is seen? Why? Take off the lid and look through hole. Can the "stars" be seen? Why not? Do stars shine in the daytime? Why can't they be seen?

V. Similarities and differences exist in all phenomena. Man must learn to live in harmony with variety and his activities should enhance, rather than imperil, natural conditions.

A. Recognition of variety in the universe should lead to greater appreciation of individuality.

1. Individuals must develop skill in observation to increase awareness of variety in the environment.

Conduct various observation games such as:

1) observing the contents of a tray for a timed interval and then listing its contents;
2) observing a picture and describing it to another student;
3) observing evidences of individuality in classmates;
4) observing a scene; describing and photographing the scene; comparing description and photograph;
5) observing a brief sketch from a play and describing what was observed.

2. Each individual perceives a different self-image and responsibility for the environment.

Review and record events for one day in your life in which you contributed to pollution. Keep the record once a week for a period of time and note any changes.

Write essays on "My Role in Environmental Improvement."

Develop and conduct class skits on individual responsibility for the environment.

3. Man is a distinctive animal because of his ability to reason, yet is affected by most natural forces that affect other living things.

Hypothesize how man's intelligence makes him different from other organisms. Research to find the ways in which man is like other organisms in terms of life needs and functions. Relate findings to hypotheses. Discuss findings and revise hypotheses if necessary. Which natural forces affect all living things?

4. Man has the ability to improve the environment in which he lives through individual and group efforts.

List those improvements to the environment which require individual effort and those which require group efforts. How can a class, group of classes, or entire school cooperate to improve their school environment? What is the role of the individual in this process?

5. Man's decision about the environment should seek to balance his desire for a quality standard of living and a means of achieving the standard which is the least detrimental to the environment.

Research the factors which led to the "Dust Bowl" in the Midwest during the 1930's. Hypothesize what could have been done to prevent this occurrence? What was done to correct this situation? How has changed technology developed procedures which would be used now?

B. In a democracy, the people give consent for increasing restrictions on resource allocation which may decrease the right of an individual to utilize resources.

1. Man has to develop respect for the rights of an individual, and the ability to make value judgments which may infringe on individual rights for the needs of a larger group.

2. Decisions must be made to balance private land use rights with the maintenance of a quality environment for the general public.

3. Individual citizens must become aware of governmental processes, resource availability and consumption, and ecological principles in order to make decisions.

Discuss rules that have been established for the classroom and school and classify them according to safety, respect for the group, and/or both. What other categories could be used? (Extend ideas generated by the children to include sharing and fair play.)

Relate these ideas to laws or regulations governing hunting, fishing, zoning, traffic, and others.

C. Individuals who develop awareness of *adaptations* which produce *variety* in plant and animal life, and the *organization, changes,* and *interrelationships* which exist in the environment can better comprehend the need for maintaining *equilibrium* as Earth *moves* through *space* and *time*.

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